Iron and Steel Engineer

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JOHN F. KELLY, EDITOR

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Published Monthly by

Association of Iron and Steel Electrical Engineers

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Walter H. Burr, Electrical and Mechanical Superintendent, Lukens Steel Company, Coatesville, Pa., President of the Association of Iron and Steel Electrical Engineers for the year 1934 and 1935.

THE PRESIDENT'S MESSAGE

The problems confronting those twenty-eight men who formed this association twenty-eight years ago are history now, but the methods employed in solving these problems and the policies adopted were such that today the Association of Iron and Steel Electrical Engineers is one of the strongest engineering organizations in America.

During the last four years the underlying principles of engineering organizations have been tested as never before, yet under these conditions this association has shown continued growth. The wisdom, foresight and judgment of the officers and directors with the hearty co-operation of the members have made this possible.

Lack of confidence brought about this—the greatest economic crisis ever experienced. What we, as a nation and individuals, need today is confidence. Confidence in the leaders of the nation, confidence in the leaders of industry and confidence in our fellow men.

During this period of depression many changes have taken place in the personnel of the organizations which we represent. Things have happened with a rapidity never known before. Problems which seemed almost unsurmountable have been solved and are now handled as a matter of routine. Yet, through it all, the steel industry has carried on and is better prepared today than ever before to handle these problems.

The association has not been unmindful of the changes which were taking place and has enlarged the scope of its activities to include sections covering not only Electrical, but also Mechanical, Combustion, Safety, Welding and Lubrication activities. Each year the relations between these sections become more closely interwoven and if the association is to maintain the position it has attained in the steel industry the problems encountered in all these sections must be solved in the same manner in which the problems incident to the Electrical Section have been solved. Then, and only then, can this association measure up to the task which it has undertaken.

In starting this new year let us pause for a moment and consider what are the benefits to be derived from the membership in this association.

Active members are afforded a personal contact with others occupying similar positions making possible an exchange of ideas which is mutually helpful and can be obtained in no other way. An opportunity is also given active members to present their particular problems before the entire section and the experience of other members on similar problems is made available.

Associate members are afforded an opportunity to contact those responsible for the requisitioning of the material used in construction and maintenance of the equipment in the steel industry. Engineering problems in the steel industry are submitted for their consideration and opportunity is given for frank discussion of the merits of various methods of solving these problems.

The annual convention affords an opportunity for the exhibition of the latest developments in equipment used in the Iron and Steel Industry in such a manner as to leave a lasting impression on the minds of those who attend.

The bound volumes of yearly transactions make possible a very complete reference library covering those problems which have to do with the steel industry. Active and associate members are afforded an opportunity to meet and enjoy a fellowship provided in no other way which, in reality, is one of the most essential things in life.

May I ask that during the coming year you support your local section in every way, encourage the officers by your attendance at the meetings, take an active part in the discussions, for they are the most valuable part of any meeting, and invite other engineers in the steel industry to these meetings that they too may share in the benefits derived from the work of this association.

Plans are nearing completion for the Annual Convention to be held in Cleveland on September 18, 19 and 20. The Program Committee has arranged unusually interesting technical papers, and the latest developments in steel mill equipment will be on exhibition. Take advantage of this opportunity to learn what is considered the best practice today and see what equipment is being used to lower production costs and reduce maintenance expense.

We must advance; he who stops is overwhelmed; he who ceases to grow greater becomes smaller; he who leaves off gives up; the stationary condition is the beginning of the end.

The newly elected officers and directors welcome the opportunity to be of service and with the co-operation and confidence which are the outstanding characteristics of the membership of this association we look forward to even greater things during the year 1934-35.

TUESDAY, SEPTEMBER 18, 1934

9:00 A. M.—Registration.

9:15 A. M.—Business Session, Ball Room, Mezzanine Floor, Statler Hotel, Cleveland, Ohio.

MECHANICAL, ELECTRICAL AND LUBRICATION DIVISIONS

Technical Session, Ball Room, Mezzanine Floor, Statler Hotel, Cleve'and, Ohio.

9:30 A. M.—"Developments in the Iron and Steel Industry," by Walter H. Burr, Supt., Elec. and Mech. Depts., Lukens Steel Company, Coatesville, Pa.

10:00 A. M.—"A Review of Sheet, Tin and Strip Mills," by Stephan Badlam, Consulting Engineer, Pittsburgh, Pa.

10:30 A. M.—"Electrical Equipment for High Speed Precision Merchant Mills," by Ralph H. Wright, Ind. Engr. Dept., Westinghouse Elec. & Mfg. Company, East Pittsburgh, Pa.

11:30 A. M.—Discussion.

12:15 P. M.—Luncheon, Lattice Room, Mezzanine Floor, Statler Hotel, Cleveland, Ohio.

SAFETY ENGINEERING DIVISION

1:15 P. M.—"Industrial Relations Between the Employer and Employee."

MECHANICAL, ELECTRICAL, COMBUSTION AND LUBRICATION DIVISIONS

2:00 P. M.—"Precision Rolling Mills," by S. M. Weckstein, Asst. Chief Engr., Timken Roller Bearing Co., Canton, Ohio.

3:00 P. M.—"Mechanical Billet Chipping," by George W. Lenz, Consulting Engineer, Canton, Ohio.

3:45 P. M.—"Special Electrical Drives for Steel Cleaning and Processing Machines," by A. M. MacCutcheon, Chief Engr., and W. R. Hough, Elec. Engr., Reliance Electric & Engineering Co., Cleveland, Ohio.

7:30 P. M.—Iron and Steel Exposition visit by National Officers, National Engineering Committees, Membership and Guests, Cleveland Public Auditorium, Cleveland, Ohio.

8:00 P. M.—Reception for Maintenance Engineers of the City of Cleveland at Iron and Steel Exposition, Cleveland Public Auditorium, Cleveland, Ohio.

9:00 P. M.—Reception of the President, W. H. Burr, National Officers and District Section Officers of the A. I. & S. E. E., Iron and Steel Exposition, Cleveland Public Auditorium, Cleveland, Ohio.

10:00 P. M.—Exhibitor's Informal Dance—Ball Room, Mezzanine Floor, Statler Hotel, Cleveland Ohio. Members, Guests and Exhibitors invited.

WEDNESDAY, SEPTEMBER 19, 1934

LUBRICATION ENGINEERING DIVISION

Technical Session, Ball Room, Mezzanine Floor, Statler Hotel, Cleveland, Ohio.

9:30 A. M.—"Servicing of Steam Turbine, Diesel and Transformer Oils," by R. P. Dunmire, Vice President, Buckeye Laboratories, Inc., Alliance, Ohio.

10:15 A. M.—"The Progress of Centralized Lubrication in the Steel Industry," by A. J. Jennings, Farval Corp., Cleveland, Ohio.

11:00 A. M.—"Factors Affecting The Circulation of Oil," by Maurice Reswick, Lubr. Engr., Standard Oil Company of New Jersey, New York, N. Y.

11:30 A. M.—"New Developments in Lubrication," by G. W. Miller, Pres., American Lubricants, Inc., Buffalo, N. Y.

1:00 P. M.—Discussion.

ELECTRICAL AND MECHANICAL ENGINEERING DIVISIONS

Technical Session, Lattice Room, Mezzanine Floor, Statler Hotel, Cleveland, Ohio.

9:30 A. M.—"Electrical Characteristics of Main Drive Motors at Inland Steel Company," by Wray Davis, Elec. Engr., Allis Chalmers Mfg. Co., Milwaukee, Wis.

10:30 A. M.—"Individual Motor Drives for Run Out Tables and Coilers—Dynamic Braking through Direct Current," by F. E. Harrell, Asst. Chief Engr., and C. V. Gregory, Engr., Reliance Electric & Engineering Co., Cleveland, O.

11:30 A. M.—"Run Out Tables," by C. C. Wales, Chief Engr., Otis Steel Company, Cleveland, Ohio.

Inspection Trip—Otis Steel Company, Cleveland, Ohio.

2:30 P. M.—Special Buses, which the Association will provide and guests must use, will leave the Statler Hotel. Members, Guests and Exhibitors invited. Tickets $1.50.

4:30 P. M.—Visit the Iron and Steel Exposition, Cleveland Public Auditorium, Cleveland, Ohio. Buses will bring Inspection Trip Group to the Iron and Steel Exposition.

TENTATIVE

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SEPTEMBER 18,

TECHNICAL SESSIONS—HOTEL STATLER—IRON & ST
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PROGRAM

AND STEEL EXPOSITION

PICES

STEEL ELECTRICAL ENGINEERS

19, 20, 1934

EEL EXPOSITION—CLEVELAND PUBLIC AUDITORIUM
D, OHIO

6:00 P. M.—Exhibitors Reception and Dinner, Exhibit Hall, Cleveland Public Auditorium, Cleveland, O. **Remarks,** by W. H. Burr, Supt., Elec. and Mech. Depts., Lukens Steel Co., Coatesville, Pa.; J. A. Clauss, Chief Engr., Great Lakes Steel Corp., Ecorse, Mich., and W. E. Miller, Elec. and Mech. Supt., Bethlehem Steel Company, Johnstown, Pa.

THURSDAY, SEPTEMBER 20, 1934

COMBUSTION ENGINEERING DIVISION

Technical Session, Lattice Room, Mezzanine Floor, Statler Hotel, Cleveland, Ohio.

9:00 A. M.—"Comparative Value of Fuels as Applied to the Steel Industry," by H. V. Flagg, Comb. Engr., American Rolling Mill Co., Middletown, Ohio.

10:00 A. M.—"The Development of the Modern Blast Furnace," by Arthur G. McKee, Pres., Arthur G. McKee & Co., Cleveland, Ohio.

11:30 A. M.—"The Generation of Power in Industry by Diesel Engines Using Heavy Fuel Oils," by J. H. G. McConechy, Chief Engr., Sun Shipbuilding and Dry Dock Co., Chester, Pa., and K. E. DeRosay, Fuel Oil Engr., Sun Oil Company, Philadelphia, Pa.

1:00 P. M. — "Super-Imposed Steam Turbine-Generator Plants for the Steel Mill, by A. G. Darling, Ind. Engr. Dept., General Electric Company, Schenectady, N. Y.

2:00 P. M.—"The Control of Open Hearth Furnaces," by A. J. Boynton, Vice Pres., H. A. Brassert & Co., Chicago, Ill.

3:00 P. M.—"Theory and Practice of Inversion Heating with Gaseous Fuels with particular reference to its application in the Steel Finishing Industry," by E. B. Dunkak, Vice Pres., C. M. Kemp Mfg. Co., Baltimore, Md.

3:30 P. M.—"Propane and Butane As Industrial Fuels," by W. H. Bateman, Propane Engr., Sun Oil Company, Philadelphia, Pa., and E. A. Jamison, Eastern Manager, Phillips Company, Philadelphia, Pa.

WELDING ENGINEERING DIVISION

Technical Session, Ball Room, Mezzanine Floor, Statler Hotel, Cleveland, Ohio.

9:30 A. M.—"Developments in Welding," by G. A. Hughes, Elec. Engr., Truscon Steel Company, Youngstown, Ohio.

10:00 A. M.—"Nitrogen in Arc Welds," by Dr. P. P. Alexander and Dr. J. W. Miller, General Electric Company, Schenectady, N. Y.

11:00 A. M.—"Oxy-Acetylene Welding and Cutting in Metal Working," by W. S. Walker, The Linde Air Products Company, Cleveland, Ohio.

1:00 P. M.—"Recent Developments in the Welding of Aluminum Alloys," by D. I. Bohn, Elec. Engr., Aluminum Company of America, Pittsburgh, Pa.

1:45 P. M.—"Tube Control in Connection with Resistance Welding," by Dr. J. Slepian and R. N. Stoddard, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.

2:45 P. M.—"The Application of Meters to Welding," by Paul M. Lincoln, Director, School of Engineering, Cornell University, Ithaca, N. Y.

3:45 P. M.—"Thermit Welding—Its Economic Importance in Steel Mill Maintenance," by J. B. Tinnon, Mgr., Metal & Thermit Corp., New York, N. Y.

10:00 P. M.—Formal Reception and Dance.

IRON AND STEEL EXPOSITION

As in previous years, the Iron and Steel Exposition will be one of the features of the Annual Convention. The object of the Iron and Steel Exposition is to acquaint engineers with the status of the art in reference to the various lines of apparatus used in the Industry. Accomplishments by the use of improved devices, new applications, etc., will largely form the subjects of the papers and discussions at the technical sessions. Technical papers and discussions regarding the improvement of the quality of product and economy of operation develop the urge to make improvements. Exhibits and Expositions develop this urge into a real desire as concrete suggestions and ideas are presented in these equipment displays.

In the Iron and Steel Exposition each year, the manufacturers who service the Iron and Steel Industry are presented an opportunity to display or exhibit the new developments in their products and equipment to the engineers and executives of the Iron and Steel and allied Industries. It is at the Exposition that the engineers and executives have the opportunity to inspect, examine and have demonstrated to them just what the equipment will do for them in their plants..

IRON AND STEEL EXPOSITION HOURS

CLEVELAND PUBLIC AUDITORIUM CLEVELAND, OHIO

Tuesday, September 18, 1934—1:30 P. M. to 5:30 P. M. Evening, 7:00 P. M. to 10:00 P. M.

Wednesday, September 19, 1934—10:00 A. M. to 10:00 P. M.

Thursday, September 20, 1934—10:00 A. M. to 10:00 P. M.

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ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS

CONVENTION INSPECTION TRIP

OTIS STEEL COMPANY CLEVELAND, OHIO

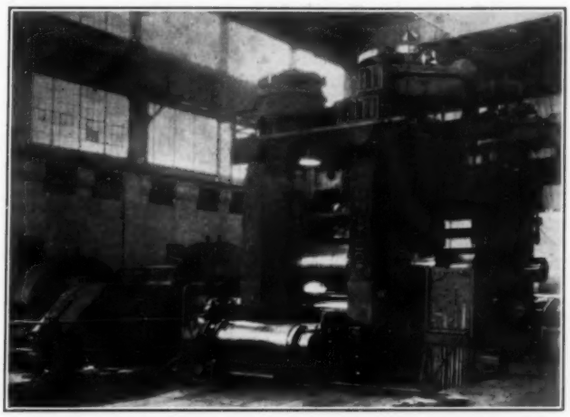
2:30 P. M.

WEDNESDAY, SEPTEMBER 19, 1934

OF PARTICULAR INTEREST

TO

STEEL MILL OPERATING AND ENGINEERING EXECUTIVES



Four High Cold Strip Mill, Otis Steel Company, Cleveland, Ohio. Delivery Side.

Features

125 Ton Open Hearth Furnaces.

42" 2 High 1 Stand Blooming Mill.

72" 4 High 5 Stand Roller Bearing Equipped Hot Strip Mill.

72" 4 High 3 Stand Tandem Cold Strip Mill.

55,000 Horse Power in Main Drive Motors.

SPECIAL EXHIBITOR'S DINNER

AFTER OTIS STEEL COMPANY INSPECTION TRIP

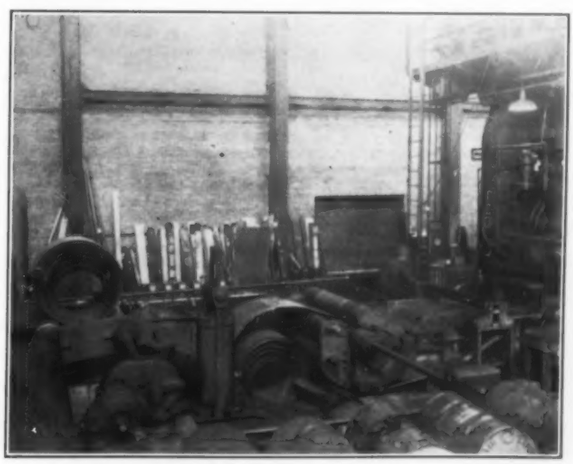
WEDNESDAY EVENING, 6:00 P M.

SEPTEMBER 19, 1934

CLEVELAND PUBLIC AUITORIUM—
EXPOSITION HALL

Tickets $1.50

Reservations must be made not later than Tuesday, Evening, September 18th, at 5:30, P. M., at Registration Desk, Mezzanine Floor, Statler Hotel.



Four High Cold Strip Mill, Otis Steel Company, Cleveland, Ohio. Entry Side.

Inspection Trip must be made in special chartered buses leaving the Statler Hotel, 2:30 P. M. Reservation for trip must be made not later than Tuesday Evening, 5:30 P. M., September 18th.

Tickets $1.50 Round Trip

Reservations may be made at Convention Registration Desk, Mezzanine Floor, September 18th, Statler Hotel, Cleveland, Ohio,

or

Association of Iron & Steel Electrical Engineers, 1010 Empire Building, Pittsburgh, Pa.

Tube Type Annealing Furnaces

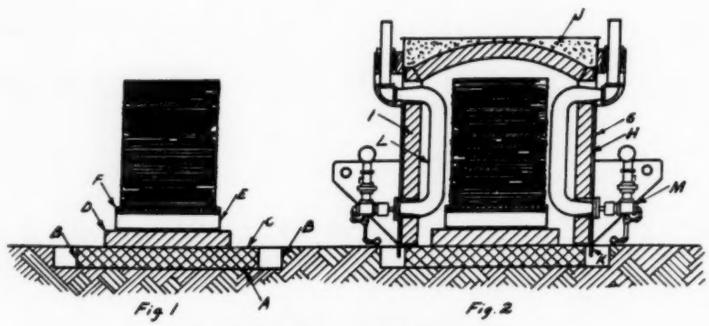
By LEE WILSON
President, Lee Wilson Engineering Company, Cleveland, Ohio.

Presented before the Combustion Engineering Division of the A. I. & S. E. E. at the Spring Engineering Conference held in Youngstown, Ohio, April 11 and 12, 1934.

Sheet annealing has become more and more important with the ever increasing demand for higher quality sheets. As the physical and surface specifications of sheets become more rigid, the demands upon the annealing departments have become more exacting.

For a time, it was thought, that the normalizing process would relieve the annealing departments of some of the burden of heat treatment. The new method of reducing strip by cold reduction has changed this picture, however. This process seems destined to eliminate the importance of the normalizing process and magnify the importance of annealing.

The demand for deoxidized or bright annealed sheets has been constantly increasing, thus throwing an even greater burden upon the annealing department.



WILSON TUBE TYPE FURNACE FOR SHEET ANNEALING

The average annealing department has been asked to get out a better and better product, and at lower costs, but in too few cases have they been given any improved equipment to work with. The fact that about 90% of the sheets annealed today are annealed in furnaces similar in design and principle to furnaces used 25 years ago, is characteristic of the lack of progress that has been made in annealing equipment.

In designing the tube type furnace, it was decided to set up a list of the necessary requirements for box annealing, and then start from the ground up and build a furnace to meet these requirements. It was further decided that present box annealing practice and furnace design would be entirely ignored. This list of requirements was based upon the assumption that if the operator had complete control of the temperature of the heating and cooling cycles, and at the same time complete control of the furnace atmosphere, he could obtain any results he desired from a metallurgical standpoint.

To obtain the best control of temperature and the most rapid heating possible, it is necessary to have as little unnecessary weight that has to be heated as possible. It is also necessary to have complete control of the heating and cooling mediums.

To obtain positive control of furnace atmosphere, it is necessary to have an air tight furnace, well sealed. If fuel is used for heating, the flame or products of combustion must not enter the furnace proper.

The tube type annealing furnace meets all of these requirements, as will be seen by the following discussion of its design and operation.

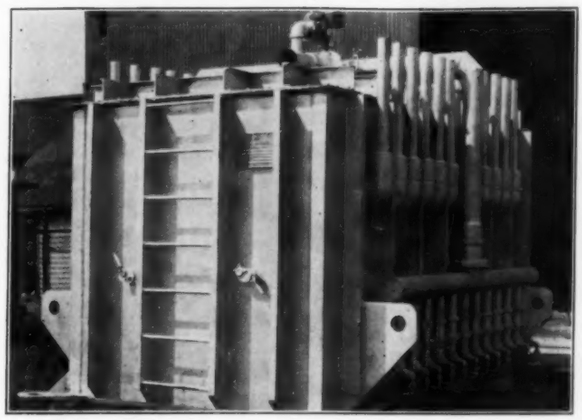
The complete furnace consists of two general parts—the base or bases, and the bell or furnace proper. Referring to Figure 1, the base, which is built on the annealing floor level, consists of a bottom plate (A) to which is welded channels (B). These channels which are welded solid to the plate form the lower half of an oil seal, and also act as a retaining wall for the pad of insulating concrete (C). The floor (D) consists of a 7½" layer of insulating brick which protects the bottom of the furnace from excessive heat loss. Rails (E) 4" in height are placed on the floor of the furnace and act as supports for a 1½" base plate (F). Sheets are piled on the top of plate (F) in the same manner as they are piled upon an orthodox annealing bottom.

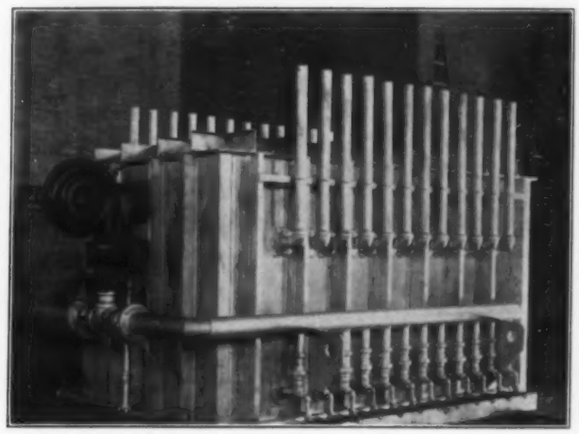
Referring to Figure 2, the furnace or bell is constructed of welded steel plate (G) formed into a rectangular case. This case is lined with one inch of sheet insulation (H) and then nine inches of insulating brick (I). A spring arch is used, which is covered with a layer of insulating powder (J), and then enclosed with the top plate of the case. The lower portion of the side and end plates (K) extend down to form the upper portion of the oil seal.

Arranged along each side wall of the furnace on the inside are twelve four inch "U" shaped alloy tubes (L). These tubes go through the side walls at the bottom and the top, as shown. Each tube is fired at the bottom with an individual burner (M) and is open to the atmosphere at the top. Fuel is burned inside of each tube and the products of combustion pass on out of the upper end of the tube. The heat is transferred through the walls of the tubes and then radiated to the pile of sheets, in the same manner that heat is radiated from an electric heating element.

Each tube is fired with an individual burner, which is so designed that accurate control of the temperature distribution in the tube is possible. The twenty-four burners are manifolded together so that fuel and air can be controlled from one main valve. This main valve is motor operated, and is opened and closed by a control pyrometer which makes the control of temperature automatic.

Air for combustion is furnished by a blower lo-





Photographs illustrating the Wilson Tube Type Furnace

cated on the top of the furnace. This blower also furnishes air for cooling purposes.

All burners, valves, air and gas piping are part of the furnace, and can be considered as a part of the furnace unit. The bell or furnace proper may be moved from one base to another, as readily as an orthodox annealing cover can be moved. The gas is connected to the furnace by a flexible hose, and the electric connection for the fan is made with an ordinary plug-in socket.

The first step in the operation of the furnace is of course the piling of the sheets upon the base. Sheets are piled by the crane in the same manner as they are piled upon a box annealing base, to a maximum height of fifty-four inches. During the piling operation, the necessary thermo-couple for control of the furnace is attached to the side of the pile. Other thermo-couples may be placed at any desired point.

The furnace is then placed over the pile by the crane, the oil seal filled and the gas and electric connections made. After lighting the burners and setting the control pyrometer for the desired temperature, the furnace requires no more attention until the heating cycle is completed. Of course, an occasional check on the pyrometer is necessary to ascertain that the couples are not shorted, or the pyrometer is in working order.

In a normal charge of twenty-four tons of thirty-six wide sheets, the edge of the pile comes to a temperature of 1450 degrees in from six to seven hours. When the edge of the pile reaches the desired temperature, the automatic temperature control maintains this temperature. When the couple located in the middle of the pile reaches the desired temperature, the operator closes the gas and air valves and the cooling cycle starts. It normally takes six to seven hours for the middle couple to reach 1400 degrees after the edge temperature has reached 1450 degrees. An average time of from 12 to 14 hours can be expected for cycles requiring the edge to be held to 1450 and the center brought up to 1400 degrees.

If it is desired to soak the charge for a definite period after the center comes up to temperature, the furnace is left on automatic control for the additional time required.

It is possible to control the distribution of heat so accurately that the bottom and top of the charge may be heated with less than 25 degrees difference in temperature during the entire cycle. In several tests it was found possible to heat the bottom much faster than the top. This condition is, of course, not to be desired, and is only mentioned to emphasize the rapid bottom heating that can be obtained with this type of furnace. A number of heats have been run in which the center bottom and center top temperature were never more than 40 degrees apart.

The transfer of heat in a pile of sheets is believed to be much more rapid from the edge to the center, than it is from the top down, or the bottom up. In the tube type furnace practically all of the heating is done from the edges. As the temperature of the furnace is controlled from the edge, overheating of any section of the charge is impossible.

Cooling of the charge is under very close control of the operator. A very slow cool is obtained by allowing the furnace and charge to cool by natural radiation. The rate of cooling in this case is about 10 degrees per hour. If rapid cooling is desired, air can be passed through the heating tubes, which then act as cooling agents. Temperature drops of 50 degrees an hour are possible with this type of cooling. As the rate of cooling in this case depends upon the amount of air passed through the tubes, any desired temperature drop from 10 to 50 degrees per hour is possible.

During the heating period, the expansion of the air in the furnace causes a pressure which is released through a check valve. As the furnace cools, a proportionate suction prevails. This suction is taken care of by bleeding gas into the furnace, to replace the air that was expelled during the heating period. In a tight furnace the amount of this gas varies between 35 and 60 cubic feet, depending upon the volume of the charge.

The cost of operating such a furnace is of course dependent upon the type of work being done, annealing cycles, and cost of fuel. Under normal conditions one fireman should be able to take care of from ten to fifteen units. The charging cost should be slightly less than charging costs with old style furnaces. The fuel cost will of course depend upon the price paid for gas, but with even 45 cents natural gas, it will not exceed the average fuel cost

obtained with hand fired coal at $2 per ton.

The following figures are conservative and can be used to obtain direct fuel comparisons:

Natural Gas of 1100 B.T.U. Value

1450 degree annealing	1300 cubic feet per ton
1350 degree annealing	1200 cubic feet per ton
1250 degree annealing	1100 cubic feet per ton
1150 degree annealing	1000 cubic feet per ton

Due to the simple rugged construction, low furnace maintenance costs can be expected. The relatively few bricks required per furnace (only 3600) reduces the refractory replacement costs.

A natural question asked by many engineers is "How long will the heating tubes last?"

This question can best be answered by stating that the furnace is designed in such a manner that the tube temperature will never exceed 1800 degrees. When natural gas is used as a fuel, the alloy people tell us that the proper alloy should give almost indefinite service. If we choose to be more conservative, however, we might say that the same life should be expected as is obtained in natural gas fired normalizing furnaces that do not exceed 1800 degrees.

The following comparison of the tube type furnace with the normal box annealing furnace and annealing sheets for galvanizing is enlightening:

	Tube Type	Old Type
First cost including all equipment	$7,500.00	$10,500.00
Replacement cost for covers and trays	None	53c per ton
Fuel cost (Tube type fired with 45c natural gas and old type fired by hand with $2.00 coal)	.59	.62 per ton
Heating time required	12 to 14 hours	18 to 22 hours

Summing up the advantages of the tube type furnace, we find the following:

1. The elimination of covers and trays, with a resultant savings of from 45 to 60 cents per ton.
2. A reduction in heating time of 30 to 50 per cent.
3. More uniformly annealed sheets of better quality due to positive control of heating and cooling cycles and furnace atmosphere.
4. Low fuel cost.
5. Low first cost.
6. A saving in floor space and the elimination of storage space for boxes and trays.
7. The elimination of dirt and sand in the annealing department.

Discussion

Discussion presented by

F. E. Leahy, Fuel Engineer, Youngstown Sheet & Tube Company, Youngstown, Ohio.

Lee Wilson, President, Lee Wilson Engineering Company. Cleveland, Ohio.

F. W. Brooke, Vice President, Swindell-Dressler Corp., Aspinwall, Pa.

D. S. Bell, Heat Treating Foreman, Edgewater Steel Company, Oakmont, Pa.

F. E. Leahy: At a previous meeting, we listened to the developments of the electrically heated furnace and the accuracy of temperature control of the product being annealed as expressed by Mr. Otis of the General Electric Company and Mr. Scott of the Westinghouse Company. It looked for a while as if the gas fired furnace would be unable to compete at all with the electrically heated furnace. Mr. Wilson with his paper gives us a different picture—a new method of firing with gas—and from the description it looks as if it may be a competitor with the same degree of accuracy of the electrically fired furnace. It would be very interesting to see what an exploration of a furnace of this type, made the same way as outlined by Mr. Scott (July issue of the Iron and Steel Engineer) would show. I am sure, on account of the many novel features involved in this, there are many of you who would like to ask the author some questions. In his paper Mr. Wilson mentioned that this furnace was used experimentally for heating sheets that were to be galvanized. I would be very much interested to know if any observations were made of the degree in which these sheets pickled compared to sheets annealed in the ordinary furnace —if there was any noticeable difference in the cleanliness after pickling?

Lee Wilson: There hasn't been any data kept on that as to the difference of pickling. The first furnace that was built in which we had enough test runs to really get some data unfortunately leaked air. It was impossible to keep all the air out. It was, of course, the first furnace built and there were several problems of construction we didn't have solved at that time, and we were continually up against the difficulty of keeping the air out. Since that time, in designing the furnace, we have eliminated those difficulties, and, although the second furnace has not run long enough to get this data, we have proven it is possible to maintain a furnace absolutely free of air. As far as the pickling is concerned we have no real data.

F. W. Brooke: I'd like to ask Mr. Wilson what is the maximum amount of natural gas that you could use in one of those tubes, and what is the most effective length you can get in the tube and still maintain reasonable uniformity? And a third point that occurred to me—does Rose's metal stand up very well without undue oxidation? We have had a lot of experience with that kind of thing in the use of lead and those various things. They usually oxidize away too rapidly.

Lee Wilson: Answering the first question, Mr. Brooke, we have found that the maximum amount of gas that can be burned in a tube of this type and shape—qualifying in that manner—is around 150 to 175 cubic feet per cubic foot of volume per hour.

F. W. Brooke: What's that?

Lee Wilson: 150 to 175 feet per cubic foot of volume—that is volume of the tube per hour. Now that will vary according to the type of temperature distribution you want; but firing as we normally do with a fairly good mixture, although not complete,

between 150 to 175 seems to be the maximum amount of gas we can burn.

The second question was regarding the length of tube, I believe, in which we found we could get uniform distribution. We have run many tests on that particular thing, not in the furnace but in the laboratory. We have found about five feet is the maximum length in which a degree of uniformity can be gotten if you burn enough gas to be able to liberate the necessary B.t.u.'s. If you go to a very stratified burning condition it is possible to heat a longer tube and heat it fairly uniformly. But if you go to that stratified condition, you are up against the problem of burning enough gas to release the B.t.u. required for heating the charge.

The next question was about the Rose metal seals. I am frank to say that we have just recently decided against the use of Rose metal for that very reason—because of oxidation. Although the seal is very small on top—the lower seal, of course, is oil because it is cold—but although the seal on the top is very small and the quantity of sealing medium is very small, we feel that it is probably better to use one of the higher temperature hardening oils; because of the fact that they do not oxidize and also because of the fact that they are much more easily applied and also are very, very much cheaper.

I think that answers all the questions.

F. W. Brooke: You mentioned 150 feet per cubic foot, which brings up that interesting point of what is the best relation of diameter to length?

Lee Wilson: That purely is a matter of opinion and it hasn't been backed up with sufficient research or experimentation to give an authoritative opinion on it.

F. E. Leahy: How frequent is it necessary to adjust the individual burners in order to maintain a uniform heat transfer from the tubes to the mass of material being heated? In the electrical furnace they have the advantage of a resistor at a uniform temperature. Is it necessary to vary the regulation during the annealing of a charge or will one setting suffice?

Lee Wilson: We found, Mr. Leahy, that once the furnace is set,—once the individual burners are set to give the proper heat distribution, there is no necessity for changing that setting. There is a possibility of having to change it, however, if you would pile different widths of sheets. In other words, if you pile sheets on the bottom, say, 36 inches wide and 18 inches high, and maybe up in the middle put a lift 30 inches wide and 18 inches high and then a lift 24 inches wide and 18 inches high, in all probability you would have to change the rate of mixing on the individual burners to take care of such a special charge. However, it isn't customary to have such a discrepancy in the widths of the charge, and I think it would be entirely possible to get away from that type of piling to a large extent. That is the only case where we find it is necessary to change the setting of the individual burners once we have them the way we want them.

D. S. Bell: I would like to ask Mr. Wilson what provisions he has made for changing the tubes in this type of furnace? We know that the alloys will burn out eventually, yet from the sketch he presented, it would seem necessary to tear down the furnace in order to replace the combustion tubes. I wonder if he has worked out some means of making this change?

Lee Wilson: The tubes are so arranged that by cutting one weld, and unscrewing the exhaust pipe, the entire tube may be pulled out of the furnace wall from the inside. A separate re-enforcing pipe the width of the wall supports the brick lining. This pipe is somewhat larger than the tube, so that the tube may be pulled through it without disturbing the brick work.

In replacing a tube, the new tube is pushed through the wall from the inside, the lower end welded to the case, and the exhaust pipe screwed into the upper end.

F. E. Leahy: What is the weight of the bell to be lifted?

Lee Wilson: The total weight of the bell on a furnace 36 by 120 is approximately 13 tons. The total weight of the furnace or, in other words, the shipping weight of the furnace including the refractory base and all is 15¼ tons.

F. E. Leahy: I also would like to ask what variation in temperature do you get between the top and bottom of your tubes? Is that controllable?

Lee Wilson: That, of course, Mr. Leahy, is controllable by the rate of mixing of the air and gas. The distribution of the temperature of the tube, of course, can be varied in that manner and is varied to give the degree of heating in the charge itself that is wanted. If it is found necessary to carry a slightly higher temperature at the bottom of the charge than at the top in order to heat the bottom center as rapidly as the top it can be regulated that way. Of course the lower portion of the tube will have to be hotter than the top to take care of that condition.

THE SEPTEMBER ISSUE

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Cleaning of Steels

By E. A. RICH
Vice President, The American Foundry Equipment Co., Mishawaka, Ind.

Presented before the Combustion Engineering Division of the A. I. & S. E. E. at the Spring Engineering Conference held in Youngstown, Ohio, April 11 and 12, 1934

E. A. RICH

The desirability of performing the function of abrasive cleaning without the use of compressed air has been recognized for over half a century and the numerous patents employing impelling wheels that have been taken out attest to the value and importance of the idea. Patents employing these ideas were taken out as early as 1870. None of these devices would work for three reasons:

First: The critical speeds were not discovered.

Second: The action of the wheel proved self-destructive.

Third: The direction of abrasive delivery could not be controlled.

The American Foundry Equipment Company does not claim credit for the basic idea but they do claim credit for segregating, utilizing and bringing under control the principles involved. The control was accomplished only after years of effort involving literally thousands of tests. No great difficulty was encountered in obtaining efficiency, but protection of the device itself and directional control proved to be knotty problems.

It was discovered that there are three important forces that must be employed to obtain results—viz: Centrifugal, tangential and air-dynamic. But the difficulty was to bring these forces under control. First there was the problem of protecting the device from self-destruction. The forces proved to be so powerful that the destructive action on the abrasive, on the housing, on the handling mechanisms, and the wheel itself nullified the value of the work done by the device. When the problem was finally solved the means, although basic, proved to be thoroughly simple.

Second—Directional control of abrasive was essential. This problem proved to be very elusive and difficult. Only after many months of experimentation and discouragement was it solved. This feature has now been developed to the extent that practically all but the rebounding abrasive can be delivered in any direction desired. When the problem was solved the means proved to be both simple and basic. It has been responsible for increasing the efficiency tremendously, as effective results can now be obtained from practically all of the abrasive thrown by the wheel, and furthermore, those parts of the mechanism which were subject to excessive wear have been relieved so that the wear is very slight. Naturally, each step of accomplishment has been covered by patent application.

The abrasive can be literally placed wherever desired; downwards, upwards; or either to the right or left side of the wheel. A cabinet built with two wheels, one above and one below the work, will clean both surfaces simultaneously.

The abrasive is thrown in a stream approximately 4″ wide. The most effective working distance being 9 to 12″ from the periphery of the wheel. The length of the effective blast stream may be varied from approximately 36″ to 10″. So thoroughly can the direction of delivery of the abrasive be controlled that it can actually be directed on an area 4″ wide and 10″ long. When the wheel axis is turned at varying angles on a horizontal plane, the width of the effective cutting stream may be varied to any degree, but of course the linear speed at which the material may be passed under the wheel will be reduced. The greater the angle the less the linear speed. Billets 4″ wide and less which pass under the wheel at right angle to the axis of the wheel are cleaned effectively at from 60 feet to 90 feet per minute, removing all scale. These speeds apply to high carbon steel such as silico carbon, 80, 90 and 100 point carbon, as well as mild steel billets. One company is cleaning one side of mild steel bumper stock billets at 70′ per minute and upwards. The surface exposed to the wheelabrator blast is 4″ wide and the wheel is placed at an angle of 8 degrees.

Skelp to be cleaned on the edge if passed under the wheel in the direction of rotation of the wheel is cleaned in a strip of about 5″ wide at from 70 to 100′ per minute. Billets 12″ wide may be cleaned at the rate of approximately 25′ per minute The wider the material cleaned the lower the cleaning speed in linear feet.

When the wheel is set at right angles to the direction of the travel of the material, the speed of cleaning is from 8′ to 15′ per minute, depending upon the condition of the material to be cleaned. The width of the effective cutting path is approximately 36″. Hot rolled sheets are being cleaned effectively by the wheelabrator at 12′ per minute. The above speed is accomplished with one wheel.

The cost of cleaning billets with wheelabrator equipment depends on the size of the billets and the number of surfaces cleaned. 4″ wide x 2″ billets have been cleaned at a cost of 20 cents per ton, not including overhead charges. Only one of the four surfaces is cleaned. One company has estimated the cost of cleaning billets 4″ x 4″ and smaller, four

sides, to be 94 cents per ton, based upon exhaustive tests on demonstrating equipment. They include a generous charge for repair parts, actual cost of power, labor, abrasive exhaustion and overhead and use an operating factor of 60% due to the conditions in their plant. The cost of pickling these billets in the same plant has been given us as $1.34 per ton. The reduction in cost of wheelabrator cleaning as compared with compressed air abrasive blasting is a great deal more pronounced. A 15 H.P. motor is individually mounted to operate each wheelabrator. Experience has shown that the effective work performed by one wheelabrator is greater than that of three 3/8" nozzles which at 70 lbs. pressure consumes 513 cubic feet of air per minute, requiring 100 H.P. to produce.

This statement is considered conservative and is based upon the experience of large motor car manufacturers and others who are operating our wheelabrator tum-blasts in cleaning castings and forgings. Various machines operating today have reduced the cleaning time 20 per cent to 50 per cent with the horsepower reduction stated.

In cleaning flat work such as billets, skelp or sheets 3—3/8" nozzles will not cover the same effective blasting surface as the stream from the wheelabrator, hence the advantage is more marked. Still another application is the cleaning of scale from steel tubes used for roller bearing cases. Some of this stock has the anneal scale resulting from over seventy hours annealing, and the producers of this material tell us that they have found no other means, not even pickling, by which this could be satisfactorily processed other than by the wheelabrator. This particular cabinet is built with one wheel, the tubes are fed at a linear speed of 12 to 25 ft. per minute and are revolved four to six times per running foot.

I am not an engineer and I am not qualified to discuss in detail the mechanical principles involved in the action of the wheelabrator. In this respect I do not differ, however, from capable and experienced engineers who have been concentrating on this problem a matter of years. Frankly, we obtain results far beyond those to be expected if we base our calculations strictly upon known formulae. I do not mean to imply that any mystery is involved and can only say that the results obtained are far beyond those that capable engineers who have worked long and intensively on the problem tell us we have any right to expect. I will, however, point out one important fact: Whereas, 3—3/8" nozzles at 70# pressure will deliver approximately 110# of abrasive per minute, the wheelabrator throws from 250# to 350# of abrasive per minute.

Regarding the wear on the wheel itself and the collateral mechanism: The greatest wearing parts are the blades which throw the abrasive. In our present model there are eight of these. They are easily replaceable and usually wear from 20 to 40 hours. Some sets have lasted as long as 70 hours. We have made innumerable tests of different materials and have made much progress in obtaining longer life of blades. These tests are being continued and all users are given the benefit of increased life resulting therefrom. When it is considered that a wheel ejects from 7½ to 10 tons of abrasive per hour at high velocity, some better comprehension of the tremendous possibilities may be had.

Discussion

Discussion presented by

E. A. Rich, Vice President, American Foundry Equipment Company, Mishawaka, Ind.
J. L. Miller, Asst. Chief Engineer, Carnegie Steel Company, Youngstown, Ohio.
W. A. Rosenberger, Chief Engineer, Pangborn Corporation, Hagerstown, Md.

A Member: I would like to ask Mr. Rich a question. In the cleaning of strip he mentioned 4 inches being the width covered by the wheel. For the piece of strip thirty or thirty-six inches wide, would you multiple wheels or how wide a wheel would you use?

E. A. Rich: One wheel. The blade of the wheel is approximately 3½ inches wide. From 9 to 12 inches below the wheel, a stream of abrasive 4 inches wide by approximately 36 inches long is thrown. There is some cutting action on either side of the 36 inch distance, but it is not as effective as the abrasive thrown within that length. By turning the shaft of the wheel in a horizontal plane, the path of the abrasive is, of course, turned at an angle. The further the wheel is turned at an angle, the slower the cleaning speed. Passing material in the direction of the travel of the wheel, we can clean billets at from 70 to 100 feet per minute. We recently ran a test for a customer on 2½ inch wide billets running 75 ft. per minute and throwing 350 lbs. of abrasive per minute. We not only removed the scale but roughened the billet to the extent that our customer figured that the billets should have been run at 180 ft. per minute and remove the scale and obtain the finish they required. We can use all the way from 60 lbs. to 350 lbs. of abrasive per minute. The wheel operates with a maximum of 15 H. P.

J. L. Miller: How does the kind and type of the abrasive affect the speed of the machine?

E. A. Rich: You use a coarser or finer abrasive depending upon the surface you wish to obtain. As I have just said, we can run the wheel at 100 lbs. per minute and obtain a splendid cleaning effect. When we increase to 200 or 300 lbs., of course, we increase the speed of the material passing under, or over, the wheel.

J. L. Miller: That's with the same abrasive.

E. A. Rich: Same abrasive.

J. L. Miller: I'm speaking of the difference in quality of the abrasive. Supposing you go from a coarser to a finer abrasive, how is that going to affect the speed of your machine?

E. A. Rich: I can't think of any tests we have made. Usually when the equipment is installed, we find the particular size of abrasive and quantity of feed that is required to perform the work and the customer sticks to that standard. I wouldn't say you get a greater speed with coarser grit than with finer, but you get, of course, a difference in the finish.

W. A. Rosenberger: I believe I can answer that

question. We have found in air blasting as well as in experimenting with centrifugal blast wheels that the finer the abrasive is—down to a certain fineness—the faster the cleaning speed. In other words,—finer abrasive cleans—on the average—faster than coarse abrasive. We have also calculated the proper wheel speeds to give results for various abrasives that are on a par with high pressure air blasting and we have found both theoretically, as well as experimentally that when you want to use shot, the wheel should have a certain speed entirely different from that required for sand, if, with the wheel, you want to equal the blasting efficiency obtainable with the high pressure air blast. But to answer your first question again, the finer the abrasive—as a rule—the faster the work is cleaned.

Blast Cleaning of Steel

By W. A. ROSENBERGER,
Chief Engineer, Pangborn Corporation,
Hagerstown, Md.

Presented before the Combustion Engineering Division of the A. I. & S. E. E. at the Spring Engineering Conference held in Youngstown, Ohio, April 11 and 12, 1934.

The subject of "Blast Cleaning" or "Sand Blasting"—a name which may be more familiar to the majority of my listeners—is so broad and embraces so many intimately related arts, that, in the short time available—I can touch but the highlights. This makes my talk rather difficult, because you undoubtedly came here to learn some thing new or at least to supplement your present knowledge. Nevertheless, I shall try to do this to the best of my modest ability, and I believe that it will be of more interest and value to you, if I succeed in explaining some of the fundamental principles and theories rather than to give you a lengthy description of known applications with which all of you are more or less familiar.

W. A. ROSENBERGER

The name "Blast Cleaning" is of comparatively recent origin and has been adopted by one industry, because the former name "Sand Blasting"—since the introduction and rapid and wide-spread adoption of metallic and artificial abrasives—did not adequately describe this process any longer. "Sand Blasting" was a good name in its time, a time when actual sand was the abrading material in 99 cases out of a hundred. Today, steel abrasives are used in practically all up-to-date installations, except in a few rare cases, where appearance of the treated surface or other considerations require the use of abrasive other than steel. On the other hand, the name "Blast Cleaning" does not imply that this process is limited to the use of sand which, indeed it is not, as I propose to illustrate further a little later on.

The history of the blast cleaning process is shrouded in mystery, as are many noble engineering accomplishments. For the purpose of this paper, permit me to give you one version, the authenticity of which I have no way of proving. However, it is taken from a paper read about 39 years ago before the Foundrymen's Association of Philadelphia, by Mr. F. C. Brooksbank, member of the firm of Tilghman-Brooksbank in Philadelphia. Mr. Brooksbank said:

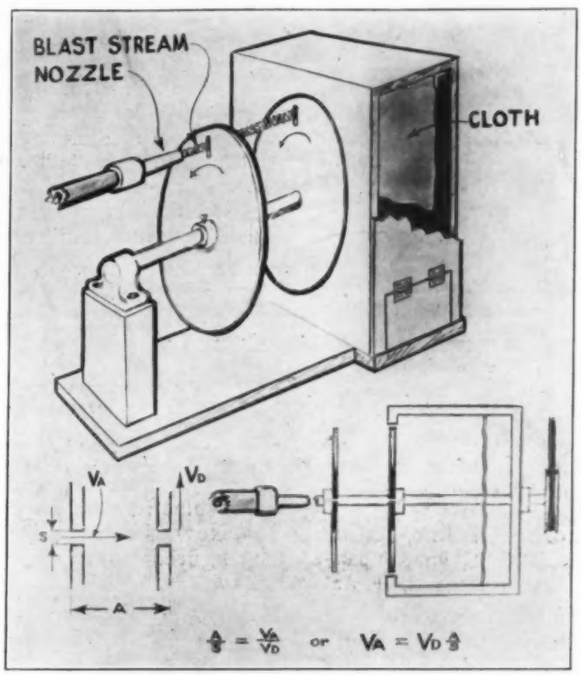
> "The invention of the sand blast process by General B. C. Tilghman of Philadelphia, Pa. in the year 1870, marked the introduction of an entirely new process into the arts. In the twenty-five years that have elapsed since that time, the process has been in constant use for an increasing number of purposes and seems destined to retain a permanent place of its own in manufacturing operations.
>
> The method, stated shortly, consist of projecting a stream of sand or other abrasive powder, usually dry, but sometimes mixed with water, with more or less force and velocity to strike and pulverize the surface of glass, stone, metal and other materials upon which it is directed.
>
> It has been frequently pointed out that in this invention Mr. Tilghman has already borrowed or adopted from nature herself, inasmuch as he has intensified and put to use a natural force, of which the effects are always apparent under favoring conditions. That is to say, whenever we find large deposits of loose sand, exposed to prevalent winds, by which it is caught up and blown against any hard substance, such, for example, as the glass in windows, the surface, with time, is sensibly roughened and sometimes scored in a manner quite distinct from ordinary weathering."

It is enlightening and certainly characteristic of the slowness with which the human mind frequently accepts and puts to use some new and seemingly advanced ideas, when we read what Mr. Brooksbank had to say—thirty-nine years ago—about abrasives.

Again I quote from his paper:

> "The abrasives used in the process include ordinary inland siliceous sand, sharp builder's sand, powdered glass, emery from fine to coarse, chilled iron sand and steel shot".

Just imagine, here was a pioneer in this line, who 39 years ago proclaimed the use of "iron sand", which is, what we today call "Steel Grit" and "Steel Shot", but it took us over twenty years to seriously consider the possibilities of steel abrasives and almost thirty years to muster up courage for an energetic and consistent campaign in favor of steel abrasives. In this campaign, if you permit me to say so, our firm has pioneered and I am firmly convinced that our efforts have not been in vain, that they have benefitted the user and have generally raised the standard of blast cleaning equipment by virtue of the inadvertent educational advertising, by introduction of improved abrasive cleaning means and methods, by better ventilation, better visibility inside of a blast cleaning room, and last but not least, because these improved conditions made many of the users of blast-cleaning equipment—what you might call: dust-conscious—so that they gradually insisted on better and better equipment, both from a human-sanitary standpoint as well as from an efficiency standpoint.



Apparatus for Measuring Abrasive Velocity.

Well do I remember the old-fashioned wooden shack, fitted with a disc fan to give some semblance of ventilation. No method of recovering the abrasive, other than a shovel and no means for removing the fine disintegrated dust from the abrasive. In those days—and I do not have to delve into past history more than about 25 years—Foundrymen, who were the principal users of sand blast, frowned at the very thought of spending one penny more for this type of equipment than was absolutely necessary to replace the old steel-wire-brush method of hand cleaning castings by something, which did the same work much better and in a fraction of the time consumed by the old hand-method.

Those were the days—and I say this without malice—when increased production at lower cost was of paramount importance, when humanitarian considerations were secondary, to put it mildly. Who, today would want a sand-blast operator to work in a room with nothing but a flimsy canvas hood to protect his head and a handkerchief tied around his nose as a protection against inhaling these deadly silica dusts? Working conditions in sand-blast rooms only 25 years ago were—with few exceptions—deplorable, compared with what they are today in an up-to-date installation.

It soon was found out, of course, that wooden sand-blast rooms were not very practical. The wood splintered away, the splinters were shoveled back into the blast tank causing frequent stops on account of nozzle-clogging. The room, itself, required continuous repairs. It was only natural to think of lining these wooden rooms with metal, which at least would not splinter. However, steel cost money and the heavier it was the more it would cost.

A good remedy for this difficulty was to prescribe the lightest possible lining that might let us get by. However, a new difficulty was experienced: this light sheet metal, under the intense peaning action of the direct and rebounding abrasive, warped out of shape, tore loose from the supporting walls and, all in all, seemed to add just another item of expense and maintenance. Some users having had experience of their own or having heard from others about these troubles, decided to solve this problem once and for all by providing blast rooms constructed from brick work. True, the brick walls did not warp anymore, but they wore away about as fast as the wooden walls and in doing so, they contributed a very liberal amount of pulverized stone, commonly known as "dust", which added to the dust created by the sand removed from the castings and by that caused by the disintegration of the sand abrasive itself, made working conditions inside of a room unbearable.

It was natural, therefore, to conceive the idea of all-steel blast rooms, which is the standard and most durable equipment. Of course, these rooms are not built out of tin, but rather from steel plates, 3/16" thick, wherever abrasives may come in direct contact.

In some instances the steel walls were lined with rubber, but until recently the application of rubber to steel was far from satisfactory. Aside from the protective value of rubber there is another advantage in its use for lining blast chambers, and that is the fact that rebounding abrasive, after it has done its useful work, is prevented from further wear or disintegration as would be the case when it is permitted to impact against steel walls.

This, briefly, is the evolution of the blast room, a description of which would, however, be incomplete without devoting a few words to that portion of an installation which is below the floor line.

As mentioned before, the first blast rooms had no provision for recovering the spent abrasive

and even today, for certain applications, rooms of this type are still favored. Prominent in this line is the Monumental Trade, whose activities are, with few exceptions, carried on on a modest scale as far as shop equipment goes. However, the more prosperous and aggressive of the monumental dealers will undoubtedly want more efficient equipment as its merits are pointed out to them.

In the foundry industry, where the blast cleaning process was first adopted, keen competition soon forced the owner to seek further labor-saving improvements, which brought about, first partially and later completely grated floors, floor hoppers, elevators and abrasive separators for the complete automatic handling and cleaning of the abrasive.

Parallel with the development of blast cleaning rooms came the development of smaller, independent blast cleaning units, such as cabinets, tables, barrels and special-purpose machines and, hand in hand with these developments, as an indispensable adjunct came improvements in methods of ventilation and dust collecting. It is the user of blast cleaning equipment, who, unknowingly and quite innocently forced industries' attention to the dust problem. From the foundry spread the gospel of dust collecting until today there is barely an industry which could conscientiously claim that the dust collecting problem is not of vital interest to them.

After this very sketchy historical outline, let us briefly scrutinize the actual process of blast cleaning. Some of the thoughts here presented, I am again borrowing from Mr. Brooksbanks' paper of about 39 years ago, because I have, in all the years I have been connected with this industry, found no clearer, no more precise, no more comprehensive explanation than that given by Mr. Brooksbank.

The blast cleaning operation is neither a cutting, grinding nor abrading process in the accepted meaning of these terms. It is entirely a pulverization of the work surface by the successive impact of the flying abrasive. To quote from the paper mentioned:

> "The sand acts much in the same manner, but on an infinitely reduced scale, as artillery projectiles in breaching a masonry wall, each grain independently of all the rest. How the sand is given velocity or how the work is presented to the blast, are matters of indifference when examining the theory of the process. As the total action of the blast is but the summation of the action of the individual grains, the action of the individual grains is to be considered."

To give you some idea of the number of grains which may be propelled against a surface, let us consider a 3/8" diameter nozzle, which discharges as much as 12 cubic feet of steel abrasive per hour. This is at the rate of 1/5 cubic feet per minute. Now, let us assume that the average diameter of the abrasive grains is 1/32" and that they fill up this space of 1/5 cubic foot in orderly rows, one alongside of the other and layer upon layer. This means that we would have 32 x 32 x 32 = 32,768 grains in each cubic inch of space, or, since 1/5 cubic foot contains 345.6 cubic inches, we find:

345.6 x 32,768 = 11,324,621 grains per minute.

Actually, these grains are not as nicely behaved as we assumed them to be. Instead of laying in orderly rows, they nest together, so that the total number will be far in excess of this figure. Let us however, compromise on 12 million grains per minute.

Now, in order that these grains may be able to change the work surface, the stress exerted by the flying abrasive particle at the point of impact must exceed the strength of the work surface.

Four factors determine this:

(1) The energy contained in the flying grain.
(2) The area upon which this energy is expended.
(3) The strength of the object struck.
(4) The strength of the abrasive particle.

Naturally, the energy contained in one single grain of abrasive is very small, but it is because this energy is expended upon an exceedingly small area that a visible destruction of the suface is possible.

Take, for instance, steel grit, having an average diameter of 1/32 inch, of which one cubic foot weighs about 275 lbs. and contains upward of 60 million particles. This then gives us:

$$\frac{275}{60{,}000{,}000} = .00000458 \text{ lbs.}$$

as the average weight of one grain.

The velocity of steel abrasive at the point of impact has been determined for an 80 lb. direct pressure blast, to be approximately 260 ft./sec.

Now the kinetic energy of such a particle may be figured from

$$E = \frac{W}{2g}V^2 = \frac{.00000458}{2 \times 32.16} \times 2.6^2 \times 10^4$$

$$= \frac{.0458 \times 16}{64.32} = .00483 \text{ ft. lbs.}$$

This is a very small amount of energy but let us consider the area upon which it is expended. This area, of course, can only be estimated possibly as follows: If we scratch a hard, smooth surface with a crystal or other sharply pointed, hard object, we find that it is easily possible to obtain scratches varying in width between 1/5000 to possibly 1/15000 inch. If we assume that the average abrasive grain, if partly imbedded in a holder and drawn over a hard surface would produce a scratch somewhere between the above limits, say 1/10000 inch in width, the contact surface at the moment of impact may then be taken as a square whose sides are 1/10000 of an inch. This means an area of .00000001 square inch upon which our energy of .00483 ft. lbs. is distributed. However, this would be at the rate of

$$\frac{.00483}{.00000001} = 483000 \text{ ft. lbs./sq. in.}$$

whereas, for example, the quiet crushing strength of granite would hardly exceed 20000 lbs./sq. in, nor would the best grade of cast iron withstand a crushing pressure in excess of 160000 lbs./sq. in. The compressive strength of wrought iron and steel would correspond to their yield points which, for the highest quality of nickel steel, probably does not exceed 75000 lbs./sq. in.

This, I believe, will in some measure explain why blast cleaning is so tremendously destructive. To harness this force, to guide it into useful channels,

to confine its effect and to direct it usefully rather than destructively, is the task of our modest little industry.

A little while ago, in our calculation, we have used an abrasive velocity of 260 ft./sec. This is an average value for #60 steel grit, determined by actual test as follows:

Two metal discs were mounted on a horizontal shaft, one of them slidable with respect to the other. The rear disc is surrounded by a box also slidably mounted on a base. The front disc is provided with a slot .2" wide, the edges of which register with the edges of a similar slot in the rear disc. Opposite the slot in the front disc is mounted a nozzle connected to a pressure-blast tank. In our tests the center line of the nozzle is parallel to the disc shaft and 6" away from its centerline. The discs were run at a speed of 1120 R.P.M which, at a point 6" from the center, corresponds to a lineal velocity of

$$V_D = 3516.8 \text{ ft./min.}$$

Now it is evident, that the distances travelled are proportionate to the respective velocities, or

$$\frac{a}{S} = \frac{V_A}{V_D}$$

from which the abrasive velocity:

$$V_A = V_D \times \frac{a}{S} = 17584a \text{ ft./min.}$$

In operation, we start with the discs a certain distance apart, say 3". We then revolve the discs and when they have reached full speed, we start blowing abrasive through the nozzle for a definite length of time, say 1 minute. If no abrasive passes the second slot in the rear disc it is an indication that the abrasive speed is insufficient for this particular setting. We then reduce the distance "a" between the two discs slightly, say 1/8" and find in another test that a few grains have passed both moving discs. These grains impinge against the curtain in the box, are collected and weighed. We can now figure the minimum velocity of these grains by simply measuring the distance "a" over the rotating discs and multiplying by 17584. For instance, if a = 3" we find the abrasive velocity for the grains collected in the box:

$$V_A = 3 \times 17584 = 52752 \text{ ft./min.}$$
$$= 879.2 \text{ ft./sec.}$$

This process is repeated with successively decreasing distances "a". When the discs are entirely closed, "a" is equal to the thickness of the two plates, in our test apparatus 5/16", which corresponds to a velocity of

$$V_{A_{MIN}} = .3125 \times 17584 \cong 5500 \text{ ft./min.}$$

or = 91.66 ft./sec.

After each test, the abrasive passing into the box is carefully collected and weighed. From the weights passing at each plate setting "a", the weight passing at the previous setting "a" was deducted and the sum of these differences represents the total amount of abrasive collected at the various velocities for the entire run. This, we call 100% and determine the percentages p_1, p_2, p_3 etc. corresponding to the velocities V_1, V_2, V_3 etc., finding the average velocity V from:

$$V = p_1V_1 + p_2V_2 + p_3V_3 + - - - - - + p_nV_n$$

For a 3/16" nozzle, flowing #50 grit, we found the following results:

Disc Distance "a"	Velocity ft./Sec.	% Abrasive passing	
2"	633.0	4.56	
1-3/4"	554.0	3.38	
1-1/2"	474.75	3.88	
1-1/4"	395.6	5.31	Aver. Vel.
1"	316.5	8.04	254.04 ft./sec.
3/4"	237.3	28.85	
1/2"	158.25	46.22	

from which we note that the highest speed observed was 633 ft./Sec. and the lowest 158.25 ft./Sec. while the average velocity V, calculated as explained before, amounted to V = 254.04 ft./Sec.

There are other ways of determing the velocities of fast moving objects, but the one just described requires a minimum of equipment and no particular skill for its application.

We have similarly tested #26 Steel Shot, #1 H Sand and #36 "Jiffy Blast", an artificial abrasive, and found for them the following average velocities:

26 Shot	210 ft./Sec.
1 H Sand	387 "
50 Grit	254 "
36 Jiffy Blast	403 "

These tests brought out a very interesting point, which may be stated as follows:

> For any abrasive devoid of concave surfaces the discharge velocity from a nozzle varies inversely with the unit weight.

Chart 1, illustrates this clearly, both for direct pressure as well as induction type nozzles. We note also that the velocity of the artificial abrasive, in each case, does not follow this rule. In an attempt to find an explanation for this seemingly peculiar behavior, we examined some of these artificial grains under a powerful microscope and found that practically every grain had one or more concave surfaces or pockets, which afforded the carrying air an excellent hold.

A few words should be said about the commonly used abrasives. As far as sand goes, it might be pointed out that only the very best grades of silica sand should be used. There is no economy in using inferior grades, because they have neither the "cutting" qualities required nor the mechanical strength to withstand repeated impacts successfully.

However, to use anything but steel abrasives today, except for special cases, would be evidence that the user is not acquainted with the present-day solution of economical and hygienic blasting.

There are two kinds of steel abrasive, namely, steel grit, which is angular and steel shot, which is spherical and from which, through a crushing process, steel grit is produced.

Steel abrasives differ from all other natural or artificial abrasives in that they are a solid, homogeneous mass, devoid of any cleavage lines....or cleavage surfaces—which are the cause of "shattering" of all other abrasives. While sand and artificial abrasives—to a more or less degree—are quickly destroyed by actually breaking apart, steel abrasives do not break, but wear away gradually—a virtue not possessed by any other abrasive.

Our Mr. Charles A. Boultman, who has made a study of abrasives for many years, says, with reference to natural and artificial abrasives:

"They are classified as crystal aggregates, meaning that they are composed of a number of tiny crystals held together by a matrix or bond to form the crystal aggregate commonly known as one grain of abrasive. The bond between the individual crystals forms the lines of cleavage. Regardless of how hard and tough these individual crystals, the resistance of a grain against shattering is equal only to the strength of the matrix or bond holding them together.

There is not a crystal aggregate which, if subjected to impact pressure within the range of commercial sand-blast pressures, will not shatter. If not completely shattered upon the first impact, two or three subsequent impacts completely reduce the crystal aggregate to its individual crystals, which are so small that they have no blasting value, being simply dust.

Every sand has its critical pressure or point of resistance to shattering. If this critical point is exceeded the sand disintegrates very rapidly."

This broken-down sand, or dust is constantly contaminating the abrasive mixture, thus reducing the efficiency of the blast. Its separation from the good sand and its collection and removal from the premises is quite expensive.

When you consider that one ton of steel abrasive will do as much work as one carload of the very best sand blast sand you can appreciate also the tremendous difference in handling expense since the ratio of

$$\frac{\text{Sand}}{\text{Steel Abrasive}} = \frac{40}{1} \text{ by weight}$$

or over $\frac{100}{1}$ by volume.

A lot more could be said about the advantages of steel abrasives, the increased production, better finish, reduced air cost, reduced abrasive cost, reduced nozzle cost, the establishing of suitable conditions for the most efficient use of steel abrasive, etc., but I am afraid we shall have to conclude this very interesting topic by calling your attention to the fact, that any finish produced with sand can practically be duplicated with the proper kind and size of steel abrasive. Furthermore, any number of intermediate effects may be obtained by suitable mixture of two or more sizes of steel grit or shot.

We now shall briefly discuss the two major types or principles used in pressure-air blasting. They are:

1—Direct Pressure type.
2—Induction type.
(a) Gravity principle.
(b) Suction principle.

In the **direct pressure principle** the full pressure of the compressed air is carried all the way to the tip of the nozzle. In order to introduce the abrasive into this high-pressure line, it is necessary to provide a pressure storage tank in which a certain amount of abrasive is also under pressure. Through an orifice in the bottom of the tank, the abrasive is permitted to flow by gravity into the high-pressure abrasive line. This is roughly the principle, but in actual practice the apparatus often is a good deal more complicated by the introduction of adjustable orifices, shut-off means for the abrasive and air, double chamber arrangement for obtaining continuous operation, etc. The direct pressure system is by far the most efficient.

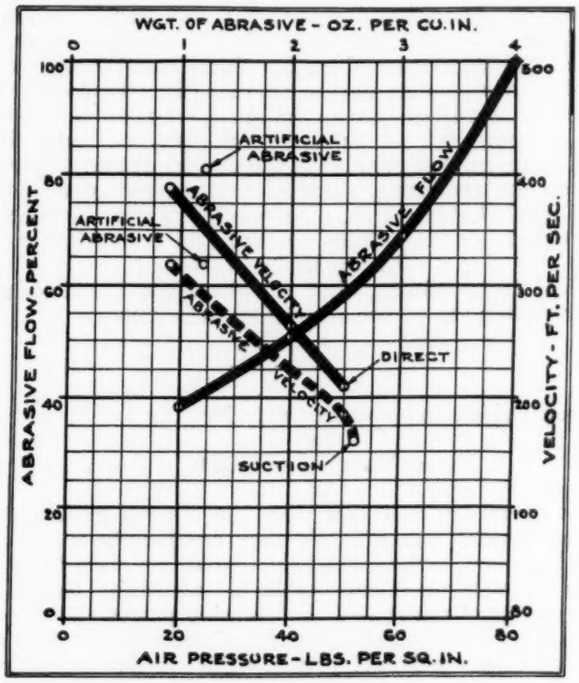


CHART 1

The **gravity principle** provides an overhead abrasive storage or other means of supplying abrasive by gravity to an induction type of gun, in which compressed air is introduced through a jet, which is in definite spaced relation to a nozzle. The air rushing from the jet into the nozzle creates a partial vacuum in the space surrounding the gap between jet and nozzle. The abrasive introduced into this gap is sucked into the nozzle, and there mixes with the compressed air, which accelerates each grain. At the nozzle tip the air suddenly expands, pressure is transformed into velocity and the grains receive a last and quite effective "shove", so to speak. This principle, while not as effective as the direct-pressure blast, is nevertheless frequently used owing mainly to its lesser first cost, as a result of the omission of the pressure tank.

The **suction principle** is very similar to the gravity principle just described, and while somewhat less effective than the latter, finds even more application particularly in the design of automatic equipment for treating materials easily cleaned. Again we have an air jet and a nozzle in definitely spaced relation but contrary to the open hopper or funnel type of mixing chamber used in the gravity type outfit, these parts are enclosed in a body, generally called a "gun". An outlet is provided at some point with provision for attaching an abrasive hose or pipe line

which leads to an abrasive feeding device often many feet away. The partial vacuum inside the gun creates a strong suction in the abrasive line, which is sufficient to lift the abrasive entering the end of the hose or line for considerable distances. However, to lift this abrasive energy is required, which is lost for useful work and this accounts for the fact that this principle is the least effective of the three.

A small, but very important part of all blast cleaning equipment, is the **Nozzle.** Nozzles are subject to wear, both at the inlet as well as at the outlet. The wear at the inlet is of concern to us because the size of the inlet controls and governs the air and power consumption.

A new ⅜" nozzle, for instance flows, at 90 lbs. pressure, about 211 cu. ft. of free air, requiring 40.5 horse powers for its production. If permitted to wear at the inlet to 7/16" diameter, the air flow increases to 286 C.F.M. (35½%) and the power to 54.9 also (35½%). It is, therefore, readily seen that it may prove to be bad economy to use a nozzle too long, particularly in equipment using multiple nozzles.

The wear at the nozzle tip is much more rapid than at the inlet. It is caused by the expansion of the air, which carries a certain amount of abrasive with it, tending to force it against the nozzle walls. This also explains why abrasives of lighter specific gravity will wear a nozzle faster than the heavier abrasives. Each moving abrasive particle has a certain kinetic energy, which is directly proportional to its weight or mass. If it were possible to fire from a double barrel gun—during a windstorm—simultaneously a cork ball and a lead ball, we would find that the cork ball would be deflected from its course much more rapidly than the lead ball, similarly, the side thrust exerted by the expanding air upon the individual abrasive grains acts quicker upon the lighter grains than upon the heavier ones.

Another cause for the rapid wear upon nozzles caused by the lighter abrasives such as sand, or artificial abrasives, is the fact that they travel through the nozzle faster than the heavier steel abrasives, because it is easier for the compressed air to accelerate a lighter particle than a heavier one. This higher velocity causes a larger volume of abrasive to flow in a given time, resulting in more frictional wear.

It goes without saying that granular abrasives—by that I mean abrasive grains which have sharp corners—cause more nozzle wear than globular grains, i. e. grains of essentially spherical shape, such as Steel Shot.

What was said about nozzle wear is also applicable to the wear of all other parts through which abrasive flows, the least wear being encountered—in all cases—when Steel Shot is used.

The length of the nozzle affects the spray or coverage at a certain distance. A long nozzle will give a more concentrated stream, whereas a short nozzle covers a larger area but shows a slightly higher abrasive velocity.

A successful attempt to reduce nozzle wear has been made with the introduction of so-called long-wear nozzles, which are equipped with a tungsten carbide liner. We have good reasons to believe that materials are known today, that can be shaped into nozzles, which will far outlast even the best tungsten nozzles. High equipment and manufacturing costs as compared with the possible market are one reason why this development has been withheld from the public, but I am confident that the nozzle problem is approaching a final and satisfactory solution.

An important matter, particularly in the cleaning of steel, is the angle between nozzle centerline and work surface. Whenever it is a matter of merely removing surface scale, it has been found that pointing the nozzles square at the work, or in other words at right angle, gives best results. The effective energy E_e of each grain varies as the sine of the impact angle

$$E_e = E \times \sin \alpha$$

When $\alpha = 90°$, $\sin \alpha = 1$ and $E_e = E$
When $\alpha = 0$, $\sin \alpha = 0$ and $E_e = 0$, which means that we have no blow whatsoever against the work surface, or, expressed differently, the abrasive flows parallel to the work surface resulting in a plain scouring action.

The next item of interest, is the air pressure. In England, Germany and possibly other European countries where this process was put to practical use first, comparatively low air pressures were used.

Brooksbank, in his paper of 39 years ago and referring to a "recently designed machine" stated

> "This machine uses air at all pressures, but those about 10 pounds to the square inch are found to be the most satisfactory".

Further on, talking about a nozzle consuming 60 cubic feet of free air per minute at 10 lbs. pressure, he says:

> "At this volume and pressure, the work accomplished on ordinary rolled steel plates is 1 square foot of scale removed per minute".

Now, one seemingly peculiar condition exists in a nozzle and that is, that the air velocity through any size nozzle, irrespective of the air pressure used for blast cleaning purposes, is practically constant. This may be proven by reference to standard air flow tables, as follows:

	⅛" Nozzle @ 20 lbs.	½" Nozzle @ 80 lbs.
CFM (Free)	7.70	340
CFM (compr.)	$7.7 \times \frac{14.7}{34.7} = 3.261$	$340 \times \frac{14.7}{94.7} = 52.77$
AREA (Sq. ft.)	$\frac{.01226}{144} = .00008513$	$\frac{.1963}{144} = .0013631$
VEL. (ft./MIN)	= 38306	= 38800

If this is true and if no other conditions were present which would in any way alter this result, one may well ask: why use high pressure when low pressure will give the same nozzle velocity? Were the advocates of high pressure systems wrong all these years? Are we, after all, coming back to low pressures?

I do not believe we need be concerned about high pressure equipment being abandoned in favor of low pressure equipment, except possibly in those cases where the cleaning action does not solely rely upon the impact of the abrasive against the work but, which is the case in Barrel blast machines, is to quite a degree helped by a purely scrubbing action as the individual pieces of work rub and slide against each other.

Another thing to consider is, whether or not

equal air velocities through the nozzle in either low or high pressure systems necessarily mean equal abrasive velocities. They do not.

First of all air at lower pressure is less dense than air at higher pressure. Therefore, it takes the low pressure air longer to accelerate an abrasive particle than is required with high pressure air. However, equally important is the effect of the expanding air at the tip of the nozzle.

Every time one cubic foot of air expands from, say 20 lbs. pressure to atmosphere, approximately .082 horse powers are released, whereas when this air expands from a pressure of 90 lbs. approximately .192 horse powers are released. Now, according to the law of conservation of energy, this power is not lost but is used, partly, in increasing the air velocity and incidentally the velocity of any other matter—such as abrasive—which may be suspended in this air.

In other words, the abrasive particles, the moment they leave the nozzle tip, receive an extra "kick"—so to speak—which is over twice as intense at 90 lbs. than at 20 lbs. pressure. (See Chart 1)

Another element in favor of high pressure is the reduction in materials required to conduct the abrasive to its ultimate destination. We have a good parallel to this in the electrical field, where high tension is used for distant power transmission on account of the conductor economies. Thus, high pressure blast equipment requires smaller nozzles, smaller hose and abrasive lines which, in turn, facilitates handling by the operator who, therefore, can work with less fatigue and more efficiency.

I do not believe that it will be necessary to loose many words about commercially obtainable standard blast equipment. You are all familiar with the common types such as **cabinets** for small and light work where the articles to be blasted are individually held under a stationary nozzle or placed upon a grill and blasted by a hand-guided movable nozzle. These outfits are particularly adapted to frail work and limited production. However, they are built for both direct pressure or suction blast.

For small work, which withstands tumbling, the **barrel type** of equipment is indicated, which is built for small or large production and again for either direct pressure, gravity or suction blast applications.

For flat work, such as stove castings, name plates, gears and gear blanks, etc. the **table machines** have been found most effective. They can be obtained with tables varying from less than 4 up to 18 feet in diameter. These large table machines have been successfully used for sanitary ware and other comparatively light but voluminous castings or other work.

For medium and large work the **room blast** is the proper equipment. The work may be carried in and placed about the floor for blasting, it may be placed on a car which is rolled into the room or the room may be provided with a trolley conveyor for handling the work. Again, when the room is used occasionally for small and medium size work, a grated work bench may be provided. Another labor saving device is a turn table, half of which projects inside, the other half outside of the room. This enables a helper to load up the outside half with new work, while the operator blasts a load on the inside half. These tables are made floor-level for larger work or raised above the floor for smaller work.

The applications for blast cleaning in the steel industry are manifold. Equipment for this purpose, mostly automatic, has been built for cleaning: billets, blooms, slabs, merchant bars, tubing (inside and outside), structural shapes, sheet bars, sheets, plates, strip steel, pipe, skelp, etc.

Since the abrasive blast removes all scale, oxidation and discoloration, it also bares the metal surface for thorough inspection. Thus flaws, cracks and other defects are readily detected, which is the main reason for blasting billets and blooms.

In slabs and merchant bars it has been found advantageous to blast in order to remove all scale preparatory to re-rolling or cold drawing, thus reducing roll and die maintenance cost, and to disclose any surface defects, which in the finished product would be objectionable.

All other previously mentioned steel products are blasted for scale removal, generally preparatory to painting, galvanizing or application of other protective or decorative coatings or then in order to eliminate pickling, which some manufacturers claim embrittles the steel due to hydrogen deposits.

Based on 50c labor and 1c/KW-Hr. power, the cleaning cost averages about 30 cents per 100 sq. feet of surface treated. It must be noted that the cost per ton depends entirely upon the thickness of the metal and decreases as the thickness increases, other conditions being equal. For instance, a 1" thick plate, 30" x 10 ft. has a surface, on both sides, of 50 square feet, weighing 1000 lbs. To blast both sides would cost approximately 15 cents or, in other words, 30c per ton. Now, assume 16 - ⅛" thick plates of the same dimensions, weighing one ton all together. These have 16 x 50 or 800 square feet total surface and would, therefore, cost 8 x 30c = $2.40 per ton, which is eight times the amount figured for a single plate of eight times the thickness.

It is, therefore, important to make quite a careful analysis of each individual case before a decision may be reached as to the advisability of blasting. To do this, the amount of surface that can be satisfactorily blasted with a given amount of air and in a given time must be known. However, the conditions of these surfaces vary so much, that it is not possible for the manufacturer of blast cleaning equipment to establish anything approaching standard practice in this respect. The safest and quickest method is to submit representative samples for test purposes.

There is only one word of caution I should like to add and this pertains to automatic machines for blasting any kind of work. Whether such a machine is equipped with a sufficient number of stationary or a lesser number of movable nozzles for complete and uniform coverage of the surfaces to be blasted, the maximum speed of the work is limited by that slowest speed required to satisfactorily blast the most difficult portion of the work. For instance in automatic machines for cleaning steel sheets on both sides simultaneously it has been our experience that the majority, if not all the commercial sheets, seem to have a different scale on one side than on the other. It is often possible to clean one side in one pass quite satisfactorily at a speed of 50 to 90 feet per minute, whereas the opposite side, at these

speeds, may require two or more passes or, if required to be cleaned in one pass, the hard side may not permit a work speed of over 10 to 20 feet per minute. As a result the whole machine must be slowed down to the slowest speed giving satisfactory cleaning. It is our opinion that the user is entitled to and the manufacturer of sheets should aim to produce sheets with more uniform surface characteristics on both sides. Great differences in hardness and toughness of scale have even been noticed on the same side of a sheet, between the edges and the center. If this problem could be solved satisfactorily, blast cleaning of sheets and plates would become tremendously more attractive and users of steel for stamping and press work could produce more accurate work at greatly reduced cost.

As an indispensable adjunct to any blast cleaning equipment must be considered an adequate and properly designed dust collecting system.

The amount of ventilation to be provided must not only be ample to take care of the compressed air coming from the nozzle or nozzles, but must provide additional capacity to keep the blasting compartment under sufficient partial vacuum to assure infiltration of atmospheric air at all openings communicating with the outside. Depending on conditions, the velocity of the infiltrating air is figured at anywhere between 200 and 1000 feet per minute, and occasionally even more. This often requires considerable suction at the fan, depending, of course, upon the length of the piping required, the type of dust collector used and its resistance to the flow of air. Cyclone collectors, of conventional design, at rated capacity have a resistance of approximately one velocity head, which for an entering velocity of 4000 feet per minute would mean about one inch water gauge.

However, cyclone collectors are not, as a rule, designed to collect fine floating dust, which is the kind most injurious to health. For this purpose the cloth screen type of collector has been designed. The average resistance, when dry dust is introduced, of this type collector is approximately 2½" water gauge when not over 3 cubic feet of air per minute per square foot of net cloth area are admitted. The resistance of this type of collector increases rapidly when the air-to-cloth ratio is increased. For approximate calculations the following formula may be used:

$$R = .20\ X^2 + .0021\left(\frac{CFM}{D^2}\right)^2$$

which gives the collector resistance in inches water gauge for normally dry dusts. For sticky materials such as lampblack, certain metallic oxides, cement and buffing wheel dust, the calculated value should be increased by 15% to 25%. In the above formula X is the ratio of cu. ft. of air per minute per square foot of net cloth area, D the pipe diameter in inches.

The fans or exhausters used for dust collecting systems are of four general types:

1—Straight blade fans.
2—Forward curved blade fans.
3—Backward curved blade fans.
4—Multivane fans.

The fans with backward curved blades have the peculiarity that with increasing speed, the power consumed reaches a maximum and with further increase of speed gradually decreases again. In other words, if a motor is selected to meet the maximum power consumption, it cannot be overloaded. These fans, however, are sensitive to dust accumulations on the back of the blades and are seldom recommended by fan manufacturers for any application where there is a chance for dust accumulation.

The least sensitive, but at the same time least efficient is the straight blade fan, while the forward curved blade fan is more efficient and more expensive. The selection of the proper fan is a study by itself and could easily be made the subject of a lengthy discourse.

The approximate horse power consumption of a ventilating system may be figured from the following formula:

$$HP = \frac{.000158 \times ST.\ P. \times CFM}{E}$$

where: ST.P=Static pressure in inches water gauge.
CFM=Cubic feet of air per minute.
E =Static Efficiency of the fan.

From this it will be seen that we have two chances of reducing the horse power:

1—Designing the system for the least possible friction losses, which are represented by the static pressure, and
2—By selecting a fan with the highest possible efficiency and, at the same time, suitable for the application confronting us.

Another very important part of a blast cleaning installation is the abrasive recovery system, which embraces proper separation or cleaning of the spent abrasive. Coarse particles, such as fins, chips, oversize abrasive, nails, wires, threads, paper, wood splinters, etc. are apt to clog the nozzle, while an excess of fines, such as dust or very fine broken-up abrasive decreases the blasting efficiency. Both must be carefully removed.

But the best designed equipment will be comparatively inefficient unless the operator—where one is required—is made reasonably comfortable by adequate protective devices such as ventilated helmets, proper clothing, ample illumination.

As far as helmets are concerned, I might say that, while it is merely an accessory, more time, study and experimenting has been spent in the search of a really good helmet than was ever spent on any of the blast machines themselves. It is probably because the helmet comes into such intimate contact with the operator, that we have so many different types and styles to select from. The human element, individual likes and dislikes, insurance companies, repair men, purchasing agents, experts and would-be experts, all enter into the consideration at one point or another and to suit so many different ideas, opinions and tastes just simply is an impossibility.

There can, however, be little question about the following main features which a blaster's helmet should have. I am enumerating these features in the order of their importance:

1—Dust Protection or Safety.
2—Large vision field.
3—No weight on operator's head.
4—No straps around operator's face and head.
5—No metal parts exposed to blast.
6—Helmet quickly removable.
7—Ventilation both sides of vision glass.

8—Maximum strength—minimum weight.
9—Easily sterilized.
10—Low cost.

To design a helmet, which incorporates all of these points 100% is no easy matter, in fact, it has not been done as yet.

Before concluding my talk, I should like to spend a few minutes with you discussing Troubles.

For years we have kept an accurate and faithful record of complaints, which we record both, under customers names, as well as against the particular machine or equipment involved.

I venture to say that 85% of all complaints can be traced back, directly or indirectly, to bad housekeeping. Too often the blast equipment is treated as a stepchild. While other machines around the plant receive regular inspection and maintenance and are kept reasonably clean and well lubricated, the blast equipment, being generally located outside of regular production lines, is neglected until part of it breaks down. To correct this, blasting equipment should receive regular inspection and any part badly worn or otherwise defective should be replaced before it gives away entirely. A reasonable supply of wearing parts should always be kept on hand and automatically re-ordered, when the stock records have reached a predetermined minimum.

Of the remaining 15% of the troubles the majority are traced back to moisture in the compressed air, which is most prevalent in summer time and more so in coast locations than inland. This moisture is practically always condensed atmospheric humidity and there is only one sure way of eliminating this trouble and that is by lowering the dew point of the compressed air before it enters the blast equipment. This can be accomplished by means of properly designed after-coolers or pre-coolers. However, in all cases certain precautions must be observed in laying out the compressed air piping such as the provision —at proper points—of "waterlegs" and tapping into mains from the top, rather than from the side or bottom.

Another not infrequent complaint pertains to static electricity. This is created by air and abrasive friction against the side walls of the abrasive hose line and is, what you might call a winter complaint.

Remedies consist of slipping a soft, preferably braided wire weave, approximately three to four feet long over the nozzle end of the hose, and grounding the end of the weave most removed from the nozzle. As long as the operator grips the hose over this protected section, he is not bothered with static. Another remedy has recently come on the market in the shape of "Non-Static" hose, which is lined with a specially compounded rubber.

Frequent clogging of the nozzle is generally an indication of inadequate abrasive separation, which permits coarse particles to enter the abrasive line or is due to nozzles being too small for the abrasive used.

Irregular abrasive flow may be caused by an excess of fines, i.e. dust in the abrasive or by light refuse such as threads, straw, paper, moist abrasive, which temporarily obstructs the flow.

Jumping of the hose is an indication of too rich an abrasive mixture and can be readily remedied by reducing the amount of abrasive fed to the hose.

I should like to discuss with you some of the troubles peculiar to certain types of equipment, but am afraid time does not permit.

As to the future of blast cleaning I can give you but my own personal opinion which, to many of you, may appear to be over-conservative. However, the

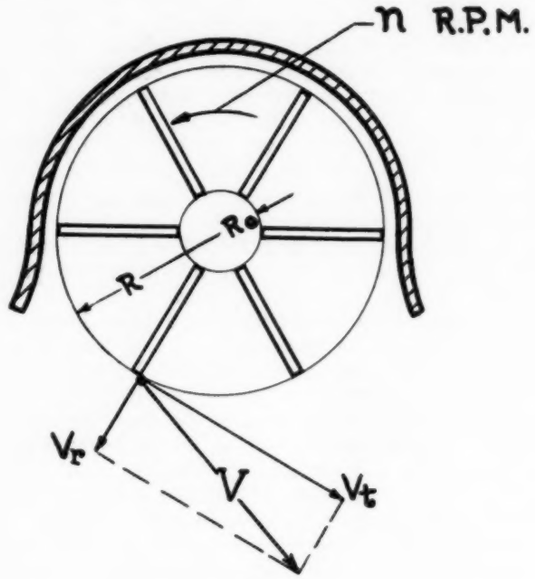


FIG. 1

study of patent literature, the analysis of the development of our own and of competitive equipment here and abroad, leads me to believe that we are approaching the point when outstanding new developments are becoming fewer every year. Improvements will continue to be made, to be sure, but they will be more along quality lines than along novelty lines.

Users of blast equipment in many cases have not availed themselves of the best that is to be had today. The future will, therefore, see a gradual move towards the purchase of the best possible equipment now available with particular emphasis on the most efficient abrasive recovery and separating system as well as on ample ventilation.

For medium size work we may—not so far hence —see the "Robot" room where the operator simply places the work upon a car, presses a button which causes the car to move into the room, the doors close and the blast starts automatically. The progress of the work may be observed from the outside. The pressing of another button stops the blast, opens the doors, starts the car to move out while a second car, with new work, automatically moves into the room. The only work left for the operator to do is the turning of the work to expose other surfaces to the blast and this is done outside of the room.

For larger work and particularly large cored work, the Hydroblast will become more and more popular. Instead of compressed air and abrasive, the cleaning medium used is high pressure water directed against the work through long nozzles on universal mountings, which permit pointing the nozzle or nozzles in any desired direction. Pressures of 300 to 500 lbs. per sq. inch are used. The water drains into underground settling chambers where all heavy matter is deposited so that the water can be

used over and over again. This process is abolutely dust-free and is the fastest, most efficient and most economical method yet devised for removing large cores.

Another method, recently revived and receiving considerable interest at this time is the centrifugal blast. It consists, in principle, of a fast revolving paddle wheel, similar to a fan wheel, but instead of air a certain amount of abrasive is admitted at or near the center of the wheel. Centrifugal force throws this abrasive to the tip of the blades where each grain is projected into space in the direction of the component of the velocity due to centrifugal force and the tip speed of the blades or vanes.

Referring to Fig. 1, V_r is the radial velocity due to centrifugal force and V_t the tangential or tip velocity of the blades. It is easy to show that the resultant velocity V of these two, for straight vanes is:

$$V = \frac{\P n}{30} \sqrt{2\ R^2 - R_o^2} \qquad \text{ft./Sec.}$$

It will be noted that in this formula the character of the material, as expressed by its weight or mass, does not appear anymore, the abrasive velocity being solely dependent upon the geometrical proportion of the wheel and its speed.

This formula, therefore, permits us to determine the proper RPM (n) of a given wheel, required to at least equal the hitting power of a high pressure blast, by transcribing it as follows:

$$n = \frac{30\ V}{\P \sqrt{2\ R^2 - R_o^2}}$$

For example, if we assume an 18" dia. wheel with 6" long blades, we have R = .75 ft. and R_o = .25 ft., and, substituting these values in above equation we find:

$$n = 9.2 \times V$$

and if we substitute for V the abrasive velocities previously given for direct pressure blast, we find the following values for wheel speeds resulting in equal hitting power as abrasive coming from a direct pressure nozzle:

Abrasive	Velocity ft./Sec.	RPM of 18" dia. Wheel
26 Shot	210	1940
50 Grit	254	2340
Sand (1H)	387	3560
Artificial Abr.	403	3720

There is no doubt regarding the hitting power of a centrifugal blast wheel and no doubt about the power saving as compared with the air blast but, whether the ultimate cost of blasting per square foot of surface or per ton of work produced, favors in all cases, one or the other of these methods, remains yet to be definitely established.

One great disadvantage of the centrifugal blast is its lack of flexibility. The wheels available at present, as far as I know, are only suitable for blasting downwards. Wheels may, however, be designed for blasting sideways, but to blast upwards does not seem to be very practical for various reasons. This means that for sheet and plate cleaning machines, it will be necessary to either pass the work through the blast twice, turning the sheets between blasts or then to provide machines in series with a turn-over position between the two blast machines. For light gauge sheets it has been found necessary to blast both sides simultaneously to avoid undue warping and it is, therefore, doubtful whether the centrifugal method can be successfully applied to this kind of work. However, the centrifugal type of blast has many features doubtless attractive, such as the omission of pressure tanks, abrasive lines, air lines, valve fittings, etc. and while I do not believe that it ever will or can entirely replace the air blast in all its applications, it will find increased use in certain fields and more so as materials are found which have greater resistance against wear than what is available for application at present.

As far as the steel industry is concerned, it is my judgment that blast cleaning will receive more attention in the future than ever before. In the same measure as your engineers and research departments are able to solve your big production and manufacturing problems will they find time to devote to refinement of processes with a view to further improvements in quality and uniformity of their products and this not withstanding the fact that not only your manufacturing methods, but also your products are second to none in the world.

The blast cleaning industry—small as it is—is at your service, gentlemen, to fight with you, shoulder to shoulder, for world supremacy in your chosen field.

Discussion

Discussed by

J. Malborn, United Engineering & Foundry Company, Youngstown, Ohio.
W. A. Rosenberger, Chief Engineer, Pangborn Corporation, Hagerstown, Md.
J. H. Van Campen, Engineer, Electric Furnace Company, Salem, Ohio.
Stanley McKee, Consulting Engineer, Youngstown, Ohio.

J. Malborn: After sand-blasting we found on the surface of the sheets a very fine palpable dust that soiled our cold rolling. How can we get rid of that?

W. A. Rosenberger: What kind of an abrasive are you using?

J. Malborn: We used both shot and sand—tried four different kinds—and with each one got the same trouble.

W. A. Rosenberger: You mean grit?

J. Malborn: It was a very fine dust.

W. A. Rosenberger: One of the most important things in sand-blasting with grit is thorough separation of the used abrasive. In other words, the abrasive must be washed very carefully—washed with air in order to remove all fine dust and what we call "metallic sludge" which are little particles dug out of the work, some containing carbon or graphite. All that must be removed very carefully in an efficient abrasive separating system. I do not know what kind of a separating system you had in that case, but I am confident that with the proper equipment this trouble can be eliminated.

J. H. Van Campen: Isn't it a true fact that sand blast or shot blast raises particles of metal like a fuzz on the surface, and small particles of dust adhere to this fuzz which the blasting does not take away? I have found this to be the case in cleaning

plate by shot blasting. If you put the material under a microscope you will see that the surface is all minutely raised up and small particles of dust get entrapped in this surface and the dust collector does not take it away. Therefore, it is carried out of the blasting machine, and I think that is what Mr. Malborn referred to. These entrapped dust particles are what spoils the surface of the rolls in the next operation. I believe that this will clear all points up.

W. A. Rosenberger: If that condition is met with in certain cases, it might be an indication that the air pressure used is too high. If you shoot those abrasive particles with such tremendous force onto the surface that some of them can actually imbed themselves, why then you have too much pressure and generally it will be found that reducing the pressure ten or fifteen pounds, together with the application of proper abrasive separation will overcome this trouble.

Stanley McKee: May I ask how many cubic feet of free air it requires to clean a surface of a thousand square feet of, say, skelp and how many pounds of grit?

W. A. Rosenberger: We generally figure that with a three-eighths nozzle at 80 to 90 pounds pressure, it will clean approximately—on an average—five square feet of metal surface. A three-eighths nozzle at 80 pounds pressure requires 191 cubic feet without abrasive flowing and about 85% of that when abrasive flows. About 162 cubic feet of air for 5 square feet or, for one square foot, 162 divided by 5 which is about 32 cubic feet of free air per square foot of surface treated.

Stanley McKee: That's the way I figured it. Now how many pounds of grit?

W. A. Rosenberger: Now the grit. With a three-eighths nozzle, the abrasive flow is approximately 4,250 pounds per hour, divided by 60 you get possibly 70 pounds per minute. And 70 divided by 5 is about 13 pounds per square foot.

Stanley McKee: That's all right. As long as It's above ten I'll agree with it.

Super-Refractories For The Iron and Steel Industry

By W. F. ROCHOW
Harbison-Walker Refractories Company,
Pittsburgh, Pa.

Presented before the Combustion Engineering Division of the A. I. & S. E. E. at the Spring Engineering Conference held in Youngstown, Ohio, April 11 and 12, 1934

The commonly used term, super-refractory, seems to be so comprehensive in its general interpretation, that it can hardly be defined precisely to bring out its full meaning. If, as the name is loosely used, it is taken to mean a refractory of a given type, that is appreciably better in its physical and chemical properties than the average of that class, then the definition is simple enough. For example, a super-refractory fireclay brick stands out somewhat by itself, among brick which in this discussion we will refer to as normal or regular high heat duty or first quality fireclay brick, yet as compared with high-alumina brick of even the lowest alumina content, namely 50% as commercially classified, it falls far short in refractoriness and other physical properties. To illustrate further, high-alumina brick as used in some industries are the accepted standard type of refractory for certain parts of the furnaces and in such cases are not ordinarily regarded as super-refractories. However, in some newer applications, the high-alumina refractories are quite properly thought of as special or "super-brick".

Perhaps the subject can be discussed to best advantage by reviewing some of the noteworthy developments in the improvement of refractories as well as some worth while accomplishments in the most judicious applications of various types of refractories.

Fireclay Brick

Fireclay brick, the most important refractory in the alumina-silica class, from the standpoint of widest economical utility, have passed through an evolution of important improvements in recent years. Much of the improvement must be accredited to laboratory control of both the raw materials of which the brick are made and of the finished product. The power press process in itself, is one of the most important contributions to the production of better refractories. The employment of this method of manufacture has resulted not only in brick of greatly improved workmanship and uniformity in size but also in brick having better physical properties, such as homogenous texture substantially free from laminations, and higher mechanical strength.

De-airing of the brick by means of vacuum during the forming is a new development which promises to still further enhance many of the good physical properties of power pressed brick. By this means the brick are made denser and less porous, thereby, rendering them more resistant to slag and gas penetration. Naturally this should prove especially desirable for blast furnace linings, stove linings and checkers, side walls and bottoms of heating furnaces, and other similar uses.

The grain sizing of the constituents of the brick mixture has had unusual attention in recent years. By means of a sizing approaching an optimum, the brick are improved in spalling and slag resistance as well as in both hot and cold strengths.

Further knowledge based upon large scale investigations of the firing temperature and the maintenance of oxidizing or reducing atmospheres has resulted in the production of refractories, more con-

stant in volume over high temperature ranges and of more stable mineral constitution.

Even though an increment of improvement in the special "super-firebrick" over the best regular fireclay brick be relatively slight at a material increase in cost, it has proved worth while for some uses. Such brick are manufactured commercially and are used to considerable advantage in certain applications. Brick in this class, which are measurably better in one or more properties than the average high heat duty fireclay brick are made from a special selection of clays or kaolins, or by the additions of small amounts of more refractory high-alumina materials such as diasporitic clays or the minerals of the kyanite group.

The formula for theoretically pure clay is $Al_2O_3.2SiO_2.2H_2O$ which expressed in percentages of these constituents is 39.8 Alumina, 46.3 Silica and 13.9 Water. The corresponding analysis after the water is driven off by calcination is 46.2 Alumina and 53.8 Silica. Not any clays are available which are entirely free from foreign oxides such as lime, magnesia, iron oxide and alkalies.

Fig. 1 showing the equilibrium diagram of the alumina-silica system is included mainly for reference in the review of the high-alumina refractories but it is interesting also in connection with this discussion. The alumina content of the most refractory high heat duty fireclay brick is approximately 40 to 42% or a little higher and their Pyrometric Cone Equivalent is 32 to 32½. In the class of "super-firebrick" are those having a P.C.E. of about 32½ to 34 and usually containing up to about 44-45% alumina. Slight as this difference in refractoriness between these two types of firebrick may seem, it is sufficient to account for appreciably longer service from the special brick, used where they are subjected to very severe treatment.

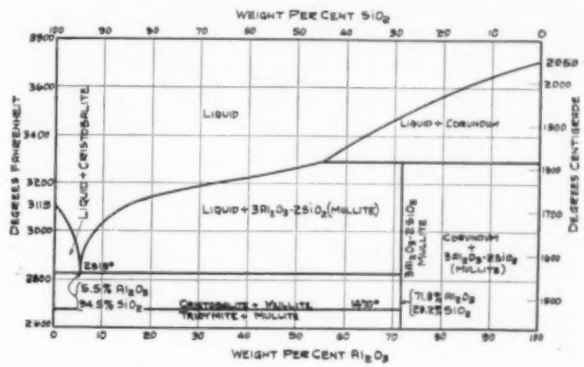
Usually the temperature of incipient vitrification of the special or "super-firebrick" is correspondingly high and to this, at least in part, is attributable a lower spalling tendency, especially over a temperature range high enough to vitrify the best high heat duty fireclay brick. On the other hand, the outstanding characteristics of some of the brick in this class are, unusual strength at high temperature, constancy of volume and low porosity, rather than spalling resistance.

From this brief description of this type of special refractory it is obvious that careful selection with respect to the properties of the brick and the conditions under which they are to be used is even more important and necessary than with the regular fireclay brick.

Special or "super-refractories" of this kind are successfully used in many types of furnaces although frequently only in relatively small quantities for such parts of the construction as must withstand unusual treatment. In electric furnace roofs, for example, substituted for silica brick they have served well in some instances, over periods of frequent interruptions and intermittent operations which induce excessive spalling of silica brick. Hot patching of silica brick construction is another use for them. Parts of various types of heating furnaces, as piers, ports, etc., are advantageously built with "super-firebrick". The outcome of other promising initial applications in the steel industry remains to be determined.

High-Alumina Refractories

While high-alumina refractories have become widely used only during the past ten years, to do without them now would leave a wide gap in the field of refractory needs. The brick in this class which are used in the largest tonnages are made from the diasporitic clays and to some extent from bauxite. For some years prior to an actual definite demand for high-alumina brick in appreciable quantities, such brick, then available were far below the standard of the best grades of the high-alumina brick on the market today. Further noteworthy improvements have been made in the manufacture of high-alumina brick in just the past several years. Along with these advances in the quality of the brick, the increase in their use has been very rapid. Here, again heavy pressure for forming the brick has played its part. Pre-calcination of a major portion of the mixture at high temperatures has added its share to the improvement, especially in reducing shrinkage to a negligible quantity. The sized texture of the brick reduces its porosity and also improves its other desirable properties, strength, spalling resistance and low shrinkage.



EQUILIBRIUM DIAGRAM OF THE SYSTEM Al_2O_3-SiO_2 (BOWEN & GREIG)

FIG. 1

The important commercial grades of high-alumina brick consisting largely of diaspore comprise the 50, 60, and 70% alumina classes. There is also an 80% alumina class of brick which are used on a lesser scale mainly because of their higher cost. However, they are used with good economy for certain purposes and their application is rapidly extending.

Typical analyses are as follows:

Approximate Alumina Content

	50%	60%	70%	80%
Al_2O_3	51.8%	61.2%	70.8%	79.0%
SiO_2	41.8	33.0	22.7	15.7
T_iO_2	2.7	3.2	3.7	2.2
Fe_2O_3	1.8	1.8	1.8	1.8
CaO	0.1	0.2	0.1	0.2
MgO	0.5	0.4	0.3	0.3
Alkalies	1.3	1.2	0.9	1.0

Refractories of the alumina-silica compositions do not have definite melting points but soften gradually at high temperatures. Chemical composition can only approximately indicate the melting point. The mineral constitution is greatly influenced by the heat treatment during firing. Mullite and Corundum are

desirable ultimate inversions. Such qualities as slag resistance, permanent contraction or expansion under heat, and strength at high temperatures, in a large measure depend upon the mineral changes which take place during the firing of the brick.

Some rather special brick in the class of high-alumina refractories are made by the addition of electrically fused alumina in a very pure form and these excel the others mainly in their ability to sustain loads at high temperature. They are well adapted for the construction of piers and muffles.

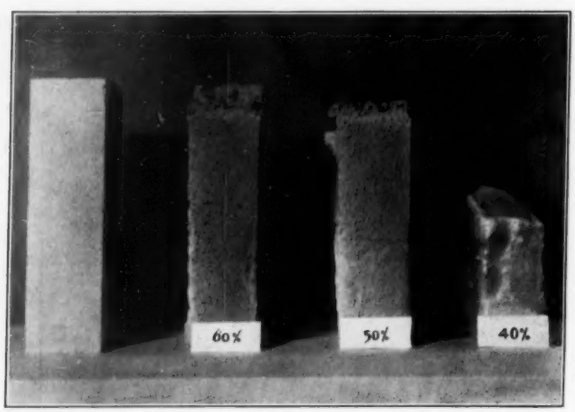


FIG. 2

Closely allied to this group of refractories are the brick of high-alumina content which are manufactured from mixtures containing kyanite and a mineral (kyanite from one source commonly referred to as sillimanite $Al_2O_3.SiO_2$) corresponding chemically to 62.9% Alumina and 37.1% Silica. Since upon proper heat treatment these minerals become more or less converted to Mullite, there remains an excess of free silica, Mullite having an alumina content of 71.8%.

In the iron and steel industry one of the most extensive uses of high-alumina brick promises to be in blast furnace stoves. Some good records have already been made in the top courses of checkers. It seems to be the generally accepted opinion that it is the comparatively high temperatures and the presence of volatile alkalies of the practically dust-free gas that cause the early destruction of fireclay brick in combustion chambers and the top courses of checkers in some stoves. The following data regarding one stove which had been in service for nine months is an example, although it is perhaps not wholly typical. This stove is located farthest from the furnace and is the first to receive the gas from the cleaning plant. A soaking heat of 2100°F. was maintained for 4 to 5 hours. An analysis of the deposit taken from the surface of the checkers at the top revealed the fact that the alkali content (K_2O, Na_2O) was 9.7%.

In this connection Fig. 2, is interesting as it shows the relative influence of alkali laden gases at a temperature of about 2400°F. upon brick of various alumina contents. For this test, standard 9 inch straight brick were set on edge, side by side, on the floor of a regenerator port of a glass tank. Obviously the brick at the extreme left was not included in the test but it is included in the photograph to show contrast. It is obvious that the high-alumina brick resisted the fluxing action of the alkali much better than did the firebrick containing 40% alumina. The duration of this test was about six months.

High-alumina brick have been used economically as checkers in open hearth regenerators. Naturally much depends upon the severity of the prevailing conditions in the checker chambers as to whether or not it will pay to use them in this application. Incidentally high-alumina brick, as compared with fireclay brick, have greater heat capacities and slightly higher thermal conductivities and specific heats.

High-alumina brick are giving satisfactory service in water-cooled ports of open hearth furnaces. The results of a number of trials of high-alumina brick in bulkheads, indicate that this may possibly prove to be another economical application at some steel plants.

Fig. 3 shows the results of tests which were made to determine the reaction temperatures between brick of various alumina contents and a typical Portland Cement clinker of the following composition, Silica 21.6%, Alumina 4.0%, Ferric Oxide, 3.0%, Lime 63.3%, and Magnesia 4.5%. The curve is here included as a matter of general interest since it illustrates the better resistance offered by high-alumina brick than by fireclay brick, to the action of this kind of flux. In the cement industry high-alumina refractories and especially those of the 70% alumina class are used for lining the burning zones of rotary kiln to a greater extent than are any other types of refractories and accordingly in that application they are not thought of as super-refractories.

In connection with some types of heating furnaces it is an interesting fact that most high-alumina brick, consisting largely of diaspore, are practically inert to the influence of certain gases and are affected to a far lesser degree by other gases than are various other refractories. Carbon monoxide even at the critical temperature range of 750°F. to 900°F. has little if any disintegrating action upon brick made from diaspore. [1]The results of an investigation of the behavior of several kinds of refractories in an atmosphere of sulphur dioxide at the temperature of 950°C., ± 25°C., (1742°F.) showed that a diaspore brick containing 68% Alumina lost no strength while the cold crushing strengths of two brands of fireclay brick, included in the test, decreased 27% and 16% respectively. The duration of the test was 72 hours. In a very recently completed study[2] of the action of natural gas (80 to 85% Methane, 15 to 20% Ethane) and hydrogen, upon several different types of refractories, neither diaspore nor silica brick were disintegrated at any temperature up to 1800°F. which was the maximum for the investigation.

Silica Brick

There may not remain much possibility of further advantageously modifying to any appreciable degree, the more or less inherent physical properties of silica brick such as heat expansion coupled with true thermal spalling. Considerable experimentation has been done with catalysts and firing schedules

[1] S. M. Phelps, American Refractories Institute, Technical Bulletin No. 9, March, 1927.

[2] B. C. Ruprecht, R. H. H. Pierce and Fred A. Harvey. Effect of Natural Gas and of Hydrogen upon Various Refractories. J. American Ceramic Society, Vol. 17, No. 7, July, 1934.

toward securing the maximum inversions from quartz to tridymite and cristobalite. Some slight improvements have been secured and the work continues on. Power pressing of standard sizes of silica brick such as can be made practicably by this method has resulted in brick of unusually good workmanship. The homogeneous texture and freedom from air-pockets and molding cracks, in a large measure, accounts for the longer service secured from them. The thermal expansion curve for power pressed silica brick is the same as for those made by the hand molding and gravity machine methods, all other factors being equal.

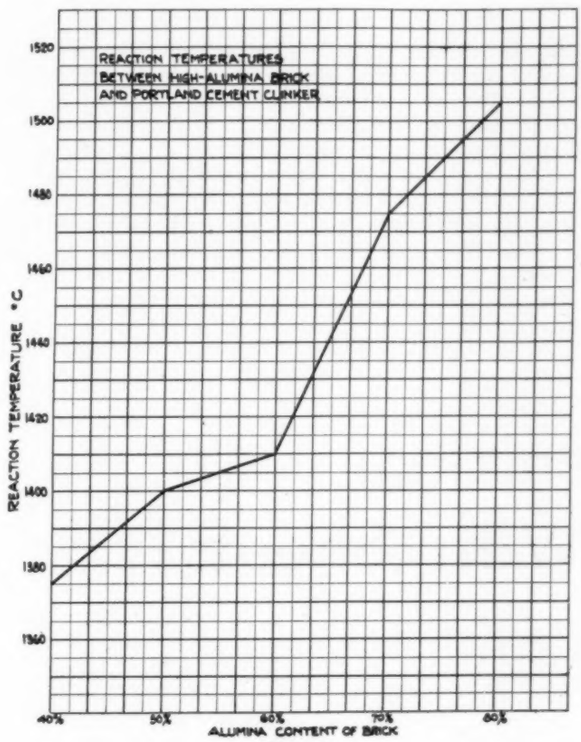


FIG. 3

Breakage, or as it is frequently interpreted, "pinch spalling" of the brick in walls and roofs, attributable primarily to warpage, is reduced to the minimum by the use of power pressed brick. The benefits due to the absence of molding defects are obvious. This method of manufacture of silica brick, for a given quartzite, reduces the porosity and consequently, the mechanical penetration by slags, with which they come in contact in the furnaces, is also reduced.

Basic Refractories

Among new developments in the production of basic refractories are some which have definitely proved their worth. Magnesite brick of low-iron content are produced, which have decided advantages over the usual magnesite brick for certain applications. Briefly comparing the properties of these two types, the low-iron brick possess greater strength at high temperature, spall less after being subjected to high heats, have higher magnesia content and about the same porosity. The benefits of these desirable qualities are secured from their use in exposed walls at high temperatures. In the upper walls of some basic electric steel melting furnaces in which silica brick are inadequate for the conditions imposed upon them, the low-iron magnesite brick give sufficiently increased life to warrant their use despite their higher cost.

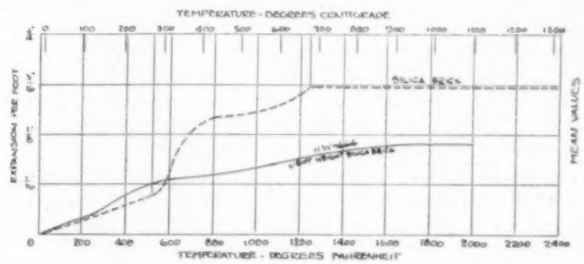


FIG. 4

Unburned, chemically bonded magnesite brick have been marketed for many years but they were not very widely used. With improvements in their properties during the past several years their use has been extended. At high temperatures, chemically bonded brick become substantially burned brick and have characteristics similar to those of the burned refractory.

Unburned magnesite brick, provided with steel casings, possess greater resistance to spalling over the entire range of furnace temperature than do regular magnesite brick. They are laid as headers so that the brick are completely enclosed with steel except at the ends. The metal at the face exposed to the heat, of course burns and melts, reacts chemically with the brick and forms an essentially monolithic surface. At a slight depth from the hot face of the furnace lining the metal remains unchanged. This increases the spalling resistance and adds to the strength of the structure.

It may be of at least passing interest to here note a few facts in connection with the use of magnesite brick in the roofs of copper reverberatory furnaces. Until a few years ago, silica brick, exclusively, were used for the entire roof construction. These furnaces are charged through fettling holes in the roof close to the walls. Severe fluxing occurs in these sections. Magnesite brick are used as shoulders in the roofs at each side, to the extent of as much as 5 feet from the skews with the center section built of silica brick for 25 to 28 foot spans. The magnesite brick sustain the load without breaking or distorting and the life of the combination roof of magnesite brick and silica brick is 3 to 4 times that of a roof built entirely of silica brick.

At one smelter where the furnaces are operated at unusually high capacities the temperatures frequently exceed 2900°F.

Suspended magnesite brick roofs on both reverberatory and melting furnaces, are proving very satisfactory at several copper plants.

Recent advances in the manufacture of chrome brick, possessing properties of greater spalling resistance and greater strength at high temperature, can be expected to contribute to longer service, by the use of these brick in some parts of open hearth furnaces.

Light-Weight Insulating Refractories

During the past few years there have been some splendid demonstrations of fuel saving resulting from the insulation of furnaces which are necessarily operated at high temperatures. The scope of furnace insulation is extended with the development of light-weight refractories having high insulating value. There are available several types of light-weight refractories, namely one made from highly refractory fireclay or kaolin and another from quartzite the same material as is used in the manufacture of silica brick. The safe working temperatures for these light-weight refractories vary from about 2500°F. to as high as 2950°F., for the light-weight silica brick.

The lightweight silica refractory, upon being subjected to rapid temperature changes, is much more resistant to spalling than are silica brick. It is evident from the expansion curves in Fig. 4 that the more uniform and lower expansion of the light-weight silica brick accounts to a considerable extent for its relatively low spalling tendency. Its insulating value is more than three times that of regular silica brick. For example, at 2800°F. the thermal conductivities are respectively 4.8 and 17.0 B.t.u./sq. ft./°F. diff./hour/in. thickness. Over a lower range of temperatures the insulating value of the light-weight silica brick is more nearly four times that of silica brick.

Some light-weight refractories are used for the construction of walls and roofs directly exposed to heat, of course, only within their safe limits as to temperature and strength. One well known brand of light-weight brick made from a very refractory fireclay and weighing less than three pounds per 9 inch straight brick (9"x4½"x2½") has a crushing strength of over 750 pounds per sq. in., which is exceedingly high for this class of refractory. The thermal conductivity of this brick is less than one-third that of fireclay brick.

Because of their high porosities, light-weight refractories should not be used where they would be subjected to the action of slags such as molten fuel ash or to corrosive volatile constituents of gases.

For furnaces operated at very high temperatures the light-weight brick, are often used for insulating the refractories of which the furnaces are built. In many instances the interface temperature between the insulating material and the refractory brick walls or roofs is higher than the usual strictly insulating brick can withstand without rapid deterioration and of course, the interface temperature rises rapidly as the refractories are consumed and the walls become thinner.

By the use of super-refractories in furnace construction, insulation becomes practicable to a greater degree and at higher temperatures.

Hot Galvanizing In Connection With Sheets

Discussion

R. J. Wean: I have been asked to discuss Mr. Cook's paper, and I want to say that Mr. Cook gave us a paper that treated the subject of galvanizing more thoroughly than any I have ever heard. He dealt very lightly with the mechanical side of it and, with your indulgence, I'd like to point out some developments that have taken place in the machinery end of the galvanizing business in the last few years.

Originally galvanizing machine housings were built up more like a battleship than anything else. Galvanizing machine housings originally were made all in sections and riveted together. A few years ago, while housings had been made forged in one piece, most of them were made with very large fusil plates at both ends, and in spite of all the reinforcing, they would give way in a very short time.

About four years ago I asked one of the large steel companies that had the necessary equipment if they could cut out this entire housing with tolerances so close that we wouldn't have to machine it, and they undertook to do it. We had to buy a whole heat of steel at the time and it took us a little while to liquidate the inventory, but it worked out fine. I don't believe that today there are any riveted housings made—I haven't heard of any for a good many years.

Now on the original machine these rolls, which were the finishing rolls as they are today, used to be driven with a chain and sprocket. When they'd turn the rolls down, which they did—they dressed them very frequently—they would change the sprocket. That would change the amount of one tooth and they'd have to figure out the reductions to take to correspond with the change of sprocket. So when they'd run at very low speeds I have actually seen the exit rolls stop and start. It was just a case where it would revolve a little bit and hesitate, and then it would revolve some more. And that gives a very wavy and uneven coating which Mr. Cook tells you is something customers don't want.

The next development, as I recall it, was a straight gear drive and changing the gears on the rolls only. That was too limited, and I suppose because they had always worked with the finishing roll the next development in connection with that was a gear change box which gave—I don't recall how many changes, but each gear change was equal to an eighth of an inch change in diameter of the roll. But in spite of that you still had in any gear change like that considerable backlash; and, when you'd get down to 8 and 10 feet per minute for cer-

tain gauges, that backlash still gave chatter and uneven rotation to the rolls.

About three or four years ago, due entirely to the necessity of a customer who had equipment and who wanted to make an order at five feet per minute, we were asked to find out how to keep those rolls going without any chatter—without any of that backlash. So we devised a drive—put the gear change on the drive that drove these two rolls (finishing rolls), put a worm drive right sock up against these rolls (finishing rolls), so there was no backlash at all and made all of our changes for speed on these two pair of rolls (finishing rolls and bottom pair of rolls).

This pair of introduction rolls is relatively unimportant as to speed and diameter. The lower rolls I don't think are changed during the entire week are they, Mr. Cook?

Nelson E. Cook: No.

R. J. Wean: Then another new project came up and we got into the electrical control phase of the galvanizing machine for the first time. On that unit we drive this first pair of rolls (introduction rolls) and these four rolls (bottom rolls and finishing rolls) from separate motors. Through an M.G. set we set the speed of this and regulate it at any speed we want. We do the same with these others. Then we interlock the control and run on that basis. I think that was the first venture using modern electrical hook-up for controlling the speed of the various separately driven where each—the introduction rolls, the bottom rolls and the exit rolls—has its own motor. And I believe that with that development many of the troubles that the galvanizers have had are going to disappear because then you have a fixed relationship. Every galvanizer has his pet guide shape—with a definite mechanical lock if you start pulling against a guide and marking the sheet it's hard to find just where it is. You're down in the metal and everything is hidden. But with the electrical hook-up you can very easily make your adjustments to eliminate the trouble either on the top or the bottom wherever it may be, set your master control, and go on, changing at any time that it may become necessary due to the bottom rolls picking up coating or wear.

Now mechanically, the galvanizing machine up to the last few years has been a rather crude piece of machinery; and I think that along with the electrical developments the general metal coating of the steel is being given a great deal of attention. I think that the mechanical control of spangles is a known factor now, and coatings can be regulated by the prior preparation of the base metal. You can regulate the amount of coating, whether you want a heavy or tight coating, by regulating the treating of the base metal.

There are still many things that can be done with the machinery to dress it up, but I believe that by-and-large most of the new machines today can be operated; whereas, it wasn't more than four or five years ago that every machine that was built had to be rebuilt before it was right.

I made a few notes here, but I think I have covered most of them. I think that the metallurgical side of coating is really only getting its proper study

J. H. Van Campen: I would like to ask Mr. Cook some questions regarding the production of tight coat zinc sheets. I would like to know which product from a hot mill or cold mill produces the best tight zinc sheets. Suppose we have a cold rolled sheet which comes from a backed up cold mill, which cold rolled sheet naturally has a very smooth, dense surface. Then suppose we have a sheet which comes from a conventional hot rolled mill, which I think we can assume has a surface rather ragged and more or less porous. The problem today, I think, that confronts the industry is whether or not we have satisfactorily produced a tight coat zinc sheet from the cold rolled mill product, and if such is the case I would like to get some enlightenment from Mr. Cook to explain to me what the preceding method is to prepare the surface of a cold rolled sheet, in order to obtain a satisfactory tight coat zinc sheet.

Nelson E. Cook: I would like to answer the question regarding the tight coating of a cold strip product very briefly, in this way: the cold rolled product is, of course, a relatively new product, and at the present time, it probably is not possible to produce as tight a coated sheet on this product as on a sheet mill sheet, mainly because we have not had sufficient experience with it as yet. We know that the cold rolled sheet is very dense and smooth surfaced, and we know that these properties are not conducive to tight coating. However, I am not prepared to say at this time that it will not be possible to produce a tight coated sheet from the cold rolled product. On the contrary, I think that such a thing will eventually be entirely possible.

We do not want to overlook one thing in the discussion of tight coatings — that there are several things to be done that we have not as yet touched upon. We are experimenting more and more each day. There are several methods of treating a sheet before coating. Probably six or seven different methods have been used, experimentally, of course, that cannot be discussed now, which will aim in the near future toward producing a tighter coating on cold rolled product. I will sum up this discussion by saying that we are not now producing as tight a coating on this product as on sheet mill product, simply because we have not had sufficient time to gain the necessary experience.

I would like to reply to Mr. Wean very briefly.

This very comprehensive paper, Hot Galvanizing in Connection with Sheets, which was presented at the Spring Engineering Conference by Nelson E. Cook, General Supt., Galvanizing Operations, Wheeling Steel Corp., Wheeling, W. Va., in Youngstown, Ohio, April 11 and 12, and which was published in its entirety in the April issue of the Iron and Steel Engineer, aroused quite a bit of discussion which is presented in the following columns. Those who contributed discussion are: R. J. Wean, President, Wean Engineering Co., Warren, O.; Nelson E. Cook, Gen. Superintendent of Galvanizing Operations, Wheeling Steel Corporation, Wheeling, W. Va.; J. H. Van Campen, Engineer, Electric Furnace Company, Salem, Ohio; E. A. Rich, Vice President, American Foundry Equipment Company, Mishawaka, Ind., and J. Malborn, United Engineering and Foundry Company, Youngstown, Ohio.

I agree with most of the remarks he has made concerning galvanizing machines. They have been very crude—in some cases much more crude than others. Some of them have been almost so crude that they could not be successfully worked at all. His idea of regulating the speeds of the three different sets of rolls in the machine to the proper relative speeds and then tying up his electrical equipment in such a manner that they will continue to operate that way, is a very good one. However, it still is not fool proof. The man that is operating the machine still must know which pair of rolls or pairs of rolls he wants to be moving faster than the others, and unless he knows that, he will certainly not be able to tie up the rolls in the proper relation to each other.

The idea of the rigid machine, of course, is a very good one, and and has been generally used for some time. In regards to galvanizing machines I would like to leave this thought with you before I close: there will very probably be a great many developments in galvanizing in the next few years which may make such a type of galvanizing machine as Mr. Wean has pictured entirely out of date. We have done so much research lately on the chemical side of the coatings, on the bonding of coatings, preparing of sheets and all that sort of thing, that that is entirely possible; and I think in the near future our present type of galvanizing machine may be entirely out of date. At least, we are working along those lines at the present time.

I want to thank Mr. Wean for his kind remarks regarding my paper.

E. A. Rich: I think that it was said to be hard to get a surface on cold rolled sheets so that a coating would stick. We have made successful tests on cold rolled sheets and the customer told us they turned out very satisfactorily. I want to let you know there is a method of preparing cold rolled sheets for that purpose. We will be glad to make a test for anyone.

J. Malborn: I would like to ask Mr. Cook a few questions. At the beginning of his paper he mentioned the fact that the size of the spangle can be governed somewhat by the surface of the sheet. I would like to ask Mr. Cook whether he feels the size of the spangle is governed entirely by the condition of the surface of the sheet or more by the temperature of the bath or by adding some other metal to the bath?

Nelson E. Cook: In my paper I mentioned that the surface of the sheet, of course, had quite a tendency to change the spangled effect, but I also mentioned that there were several other variables that could be used to counteract that condition. If you get to the point where you have a sheet that produces a small spangle, you may introduce one or several of these variables to attempt to improve the spangled effect. The ultimate result will probably not be as good as if the sheet surface were not in that condition, but you still have all those variable to use.

I would like to say to Mr. Rich that the thought covered by his remarks is one of the things I had in mind when I said that we were just not well enough acquainted with cold strip product as yet. There are several methods of treating sheets before coating which may eventaually be used successfully and which will probably be well known in due time.

SPECIAL NOTE

IRON & STEEL EXPOSITION

ONLY EXHIBITORS AND THEIR DULY ACCREDITED REPRESENTATIVES

WILL BE PERMITTED

TO SOLICIT BUSINESS AND MAKE COMMERCIAL CONTACTS

ON THE FLOOR OF THE

IRON & STEEL EXPOSITION

ASSOCIATION OF IRON AND STEEL ELECTRICAL ENGINEERS ELECTION OF NATIONAL OFFICERS 1934-1935

On a recent mail ballot the members of the Association of Iron and Steel Electrical Engineers elected the following officers for the coming year, effective, August 1, 1934:

President, W. H. Burr, Mechanical and Electrical Superintendent, Lukens Steel Co., Coatesville, Pa.

1st Vice Pres., J. A. Clauss, Chief Engineer, Great Lakes Steel Corp., Ecorse, Mich.

2nd Vice Pres., G. R. Carroll, Elec. Supt., Jones & Laughlin Steel Corp., Aliquippa, Pa.

Director at Large, C. A. Thayer, Chief Engineer, Republic Steel Corp., Youngstown, Ohio.

Honorary Director, J. Farrington, Elec. Supt., Wheeling Steel Corp., Steubenville, Ohio.

Honorary Director, E. Friedlander, Pittsburgh, Pa.

Past President, W. E. Miller, Mech. and Elec. Supt., Bethlehem Steel Co., Johnstown, Pa.

Past President, J. D. Donovan, Mech. and Elec. Supt., Republic Steel Corp., Massillon, Ohio.

Treasurer, W. S. Hall, Supt., Engr. and Const., Illinois Steel Co., S. Chicago, Ill.

Secretary, A. D. Adams, Asst. Supt., Spang, Chalfant Company, Inc., Ambridge, Pa.

Director, C. A. Kral, Asst. General Manager, Wheeling Steel Corp., Steubenville, Ohio.

Director, C. C. Wales, Chief Engr., Otis Steel Co., Cleveland, Ohio.

Director, J. L. Miller, Asst. Chief Engr., Carnegie Steel Co., Youngstown, Ohio.

Director, L. F. Coffin, Supt. Mechanical Department, Bethlehem Steel Co., Sparrows Point, Md.

Director, K. E. Dinius, Chief Testing Engr., Illinois Steel Co., South Chicago, Ill.

Director, C. C. Pecu, Lubrication Engr., Bethlehem Steel Co., Lackawanna, N. Y.

Director, E. P. Winters, Power Engr., Sloss Sheffield Steel & Iron Co., Birmingham, Ala.

Director, E. F. Blank, Dir. of Safety and Welfare, Jones & Laughlin Steel Corp., Aliquippa, Pa.

Director, C. H. Hunt, Asst. to Pres., Weirton Steel Co., Weirton, W. Va.

Managing Director, J. F. Kelly, Pittsburgh, Pa.

ITEMS OF INTEREST

PERSONNEL CHANGES

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Arthur H. Young, vice president, United States Steel Corpn., New York, has been put in charge of the combined industrial relations and safety, sanitation and welfare departments, which will hereafter be known as the industrial relations department. Harry A. Schultz has been appointed assistant to vice president and will continue in the administration of matters heretofore under his direction. Andrew R. Mathieson has been made assistant to vice president to assist Mr. Young in industrial relations.

▲

H. L. Rankin has been named manager of the Elmira, N. Y. plant of the American Bridge Co. which has been placed back in production after an idleness of two years. Formerly assistant manager of the plant, lately he has been with the company in Toledo, O.

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M. J. Czarniecki has been elected vice president in charge of sales for A. M. Byers Co., Pittsburgh, succeeding H. W. Rinearson, resigned. Mr. Czarniecki was formerly general manager of sales.

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The Louis Allis Co. of Milwaukee, Wisconsin, manufacturers of electric motors and similar equipment announce a change in the location and management of their Pittsburgh office.

The company's office will be located at 537 Oliver Building and will be in charge of Mr. J. F. Rodgers.

▲

Allis-Chalmers Mfg. Co., Milwaukee, announces the removal of its Chicago District Office to the new Field Building, 135 South LaSalle Street.

Mr. B. F. Bilsland is Manager of the Chicago District.

With this move Allis-Chalmers returns to its original Chicago location, for the new Field Building stands on the site of the old Home Insurance Building, where the general offices of the Allis-Chalmers Company were first located after the Company was organized, through consolidations, in the year 1901.

▲

Link-Belt Company announces several new appointments in its Positive Drive Division.

G. H. Burkholder, formerly of Philadelphia, is appointed Western Sales Manager of the Positive Drive Division, with headquarters at the Company's Dodge Plant in Indianapolis.

W. H. Kinkead has been made manager of sales of Link-Belt Speed Reducers, with headquarters in Philadelphia, succeeding Mr. Burkholder.

G. L. Gansz succeeds Mr. Kinkead, and will henceforth be responsible for Philadelphia office sales of the Positive Drive Division.

▲

A. B. Peterson, for many years chief of the divi-

sion of Tool and Machine Construction for the Hawthorne (Ill.) Works of Western Electric Co., has accepted a directorship on the board of the Federal Tool Corporation, Chicago.

Mr. Peterson will take charge of the sales engineering for the tool company, and direct sales of their dies, precision tools, drop forge dies and tools for the metal working industries.

▲

Kenneth Williams has been appointed manager of sales for the department of engineering and construction of Byllesby Engineering and Management Corporation, according to H. W. Fuller, vice president in charge of that department.

The engineering department of the Byllesby corporation, which has for some years practically confined its services to the subsidiaries of Standard Gas and Electric Company, is expanding its activities to include general engineering practice for independent clients. It is in this phase of the corporation's activities that Mr. Williams will be associated.

▲

WITH THE MANUFACTURERS

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A new line of explosion proof safety switches for use in Class I, Group D, hazardous locations is announced by Cutler-Hammer, Inc., Milwaukee, Wis. This new line includes both single throw, (Bulletin 4104) and double throw (Bulletin 4124) types, in standard sizes up to 200 amperes capacity. The switch is a heavy, industrial duty Type A construction, with outside operating handle, mounted in a heavy weather-proof, semi-steel cast enclosure, complying in every respect with requirements of the National Electrical Code. A precision machined flange of required width, between the case and cover, assures proper cooling of any flame which might occur from an explosion within the case, so that outside gases will not ignite. Corrosion resisting bolts hold the cover firmly in place.

Two pipe threaded conduit holes are provided in the bottom of the case and pads at the side and top of the case allow for drilling other holes if needed. Provisions are made for padlocking the handle in either position—accommodates three padlocks in "off" and three padlocks in "on" positions to meet specific industry requirements such as in steel mills, etc. Finish is black Japan.

Specific applications for these explosion proof switches include such locations as distilleries, dry cleaning plants, petroleum refineries, bulk oil stations, filling stations, gas plants, spray painting plants, chemical works, paint, lacquer and varnish works, etc.

▲

A new inexpensive device to take the place of fuses or other motor protective devices is being marketed by the Bussmann Mfg. Company, St. Louis, Mo. It is known as the Buss Fusetron.

On the outside the Fusetron looks like a fuse, but it is very different inside. It is a thermal cutout to which a fuse has been added. The two together automatically take care of the different conditions found in the starting and operation of a motor.

The Fusetron will keep a motor from burning up on slight overloads. Even an overload of as little as 25% will blow it before the motor can be damaged.

The manufacturer claims that motor burnouts due to single phasing, lack of lubrication, tight bearings and the like will not happen when Fusetrons are properly used.

Unnecessary blowing however doesn't happen with Fusetrons. They hold the heavy starting current long enough to start the motor if there is nothing wrong. They don't blow unless there is a good reason.

Fusetrons fit in standard fuse blocks. They can be obtained in 125 volt, 250 volt and 600 volt sizes in any amperage from 1/10 ampere to 30 ampere.

▲

I-T-E Circuit Breaker Company, Philadelphia, Pa., are distributing their new Bulletin 634 on Itelite Circuit Breakers. This bulletin is confined to the description of small circuit breakers for lighting and narrow type distribution panelboards. Itelite circuit breakers suitable for convertible power panels, switchboard and industrial applications are also available.

▲

Norma-Hoffmann Bearings Corporation, Stamford, Connecticut, are distributing their new Catalog 940. This 76 page Engineering Catalog contains Engineering Data Sheets, Sizes, Dimensions and Load Ratings. It supersedes F-928-A and all previous issues.

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In Booth No. 34 at the exposition conducted in connection with the Convention of the Association of Iron and Steel Electrical Engineers, to be held at the Cleveland Public Hall this coming September 18, 19 and 20, the New Ohio Lifting Magnet and Controller will be exhibited, with current on, to demonstrate its quick dropping ability and the small arcing at the control contacts.

The new Controller is equipped with Lavite indestructible arc shields and with Thyrite arc suppressor, which not only reduces the arcing but so rapidly reduces the current flow to zero as to insure quick dropping of any kind of load on the magnet. Twenty of these new Controllers have been shipped since the first of this year.

These improved devices which are made by The Ohio Electric Mfg. Co. of Cleveland, O., may be seen at Booth No. 34.

▲

The engineering section of the complete Anti-Friction Bearing Catalog of the Bantam Ball Bearing Company of South Bend, Ind., is just off the press. This section is the complementary part of the sections dealing with specific bearing types and gives detailed illustrated information concerning the various methods of bearing application and the detailed design of the component parts of the various types of bearings.

▲

Roller-Smith Company, 233 Broadway, New York City, announces the new Kathetron Out-Voltage Regulator. This apparatus is illustrated, described and listed in Catalog No. 10.

(Continued on page 306)

Look Inside

IF YOU WOULD KNOW WHY BUSS FUSES CAN SAVE YOU TIME AND MONEY

Most fuses look about the same—but they all don't act the same in the fuse clips. Why should they? Some are designed to give service and protection—others are just thrown together to sell to unwary buyers.

When you open up fuses to see what's inside you quickly learn that BUSS SUPER-LAG Fuses are different. They are made to sell too—but to sell because they give outstandingly different service.

Maybe you will be surprised to find how carefully every individual part of the BUSS design has been worked out to make BUSS Fuses give you the most dependable protection at the lowest cost. Every one of the few and simple parts has been designed to overcome some weakness found in ordinary fuses—or to provide additional features that add to the satisfaction of using BUSS SUPER-LAG Fuses.

Many of these features of BUSS design cannot be copied by others because they are protected by patents.

How Can You Learn What's Inside The BUSS Fuse?

That's easy. Just ask the BUSS Fuse Man when he calls on you, or if you prefer to go into the matter by yourself, drop us a line and we will send you "The Story of the BUSS SUPER-LAG Fuse" in handy booklet form. Let's get together on this protection problem.

BUSSMANN MFG. COMPANY, St. Louis, Mo.

A Division of the McGraw Electric Company

BUSS SUPER-LAG FUSES

A. I. & S. E. E.—TWENTY-SEVEN YEARS OF ENGINEERING SERVICE TO THE IRON & STEEL INDUSTRY

(Continued from page 304)

The Clark Controller Company, Cleveland, O., has recently issued a new and completely revised catalog. Control information in it is, seemingly, not only complete but the information is readily accessible in assisting engineers in estimating prices, writing of specifications and in the selection of proper control apparatus for any given application. Cross-referenced, alphabetically arranged index, makes the use of these numerically arranged bulletins readily accessible.

In addition to the complete lines of standard D.C. manual and magnetic controllers and accessories, the catalog covers the many types of complete lines of A.C. controllers for squirrel cage, wound rotor and synchronous motors up to 1250 H.P., 4500 Volts. Synchronous motor control bulletin is especially timely, for it describes the operating characteristics of the various types of control equipment with respect to starting torque, current and power factor characteristics. It is believed that these bulletins will be very useful to engineers in selecting proper equipment for the particular drives involved.

The standardized crane and mill auxiliary control bulletins cover apparatus in line with the new standards set up by the A. I. & S. E. E. co-operating with N.E.M.A.

On the whole, this new catalog is a ready reference and handbook for any electrical man interested in control apparatus.

▲

Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pa., have recently published a new publication describing the Westinghouse Type LE Photo-Relay. It describes the application, construction, operation, specifications, advantages, and list prices of these relays. These relays are applicable to all types of industrial control, light control, grading, counting, etc. The relay is available for either A.C. or D.C. circuits.

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A new close coupled gas engine driven "Shield-Arc" welder of 300 ampere, 40 volt capacity is announced by The Lincoln Electric Company, Cleveland, Ohio. Due to the close coupling feature, the new unit is much more compact and of lighter weight than previous models.

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A new line of direct-current motors, designed for those applications where dust, dirt, moisture, or other foreign matter is present in large quantities, has been introduced by the General Electric Company. The new motors are totally enclosed and fan-cooled, and are available in a wide variety of electrical and mechanical modifications—in sizes from ½ to 200 hp.

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Johns-Manville, New York, N. Y., has just published a new 48-page 7½x10" catalog on their complete packing line. Over 60 different types of packings are described and illustrated.

The new J-M Packing Catalog includes a complete table of recommendations showing the type of packing best suited for each requirement. A section is also devoted to a discussion of methods of installing packings and the factors upon which satisfactory results mainly depend.

AMERICAN IRON & STEEL INSTITUTE NOTES

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Employment in the steel industry reached the highest level in four years during June when there were 455,966 people at work, according to figures announced today by the American Iron and Steel Institute. This was an increase of 6,604 over the previous month and 117,820 over June a year ago.

Of this total, 415,547 were wage earners, which is approximately 99 per cent of the number employed at the peak of 1929 and 110,308 more than were working in June 1933.

Wages and salaries in the industry during June amounted to $49,466,664, a decrease of $2,429,267 from the previous month, resulting from a small reduction in hours, but an increase of $18,905,903 over the same month last year. Average hours per week declined from 36.6 in May to 35.7 in June. Average earnings per hour were 63.9 cents in June compared with 64.6 cents in May and 47.3 cents in June 1933.

Wage earners paid on an hourly, piece-work or tonnage basis earned $40,630,314 in June, 1934, compared with $24,441,054 during the same month last year.

The June figures disclosed the spread of work in the steel industry. While the operating rate in the industry was only 16 per cent higher in June than it was a year ago, employment had increased 35 per cent, total wages 66 per cent and the average hourly earnings 35 per cent. At the same time, the average work week was reduced 9 per cent. Although the industry was operating at only little over half its capacity, its employment was virtually the same as in 1929. The following table shows the current figures compared with a year ago:

	June 1934	June 1933	Pct. Change
All employees	455,966	338,146	+35
Wage earners	415,547	305,239	+36
Wages	$40,630,314	$24,441,054	+66
Hours per week per worker	35.7	39.4	—09
Av. earnings per hr.	63.9c	47.3c	+35
Operating rate	52.68	45.37	+16

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OBITUARIES

John E. Barkle, general manager of the South Philadelphia Works of the Westinghouse Electric & Manufacturing Company, age 53, died suddenly at his home in Swarthmore, Pa., on July 10. He had been continuously in the service of Westinghouse for 33 years.

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William J. Hampton, former vice president, general manager and director of Spang, Chalfant & Co., Inc., Pittsburgh, died in this city recently, following an operation. He retired two years ago after having been in charge of the company's mills since 1904.

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Lawrence H. Vilas, president of the Pyle-National Co., Chicago, died suddenly, July 22, upon his return to Chicago from a business trip in Texas. Mr. Vilas was born in Chicago in 1894. He was made president of the company in 1932.

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CONVENTION ISSUE

CONTAINING

Convention papers, abstracts, programs of all the technical sessions . . . Convention and exposition committees . . . Inspection trip schedules . . . Iron and Steel Exposition exhibitor lists . . . News and notes on the convention and exposition . . . It is the only official publication covering the 30th Convention and Iron and Steel Exposition of the A. I. & S. E. E.